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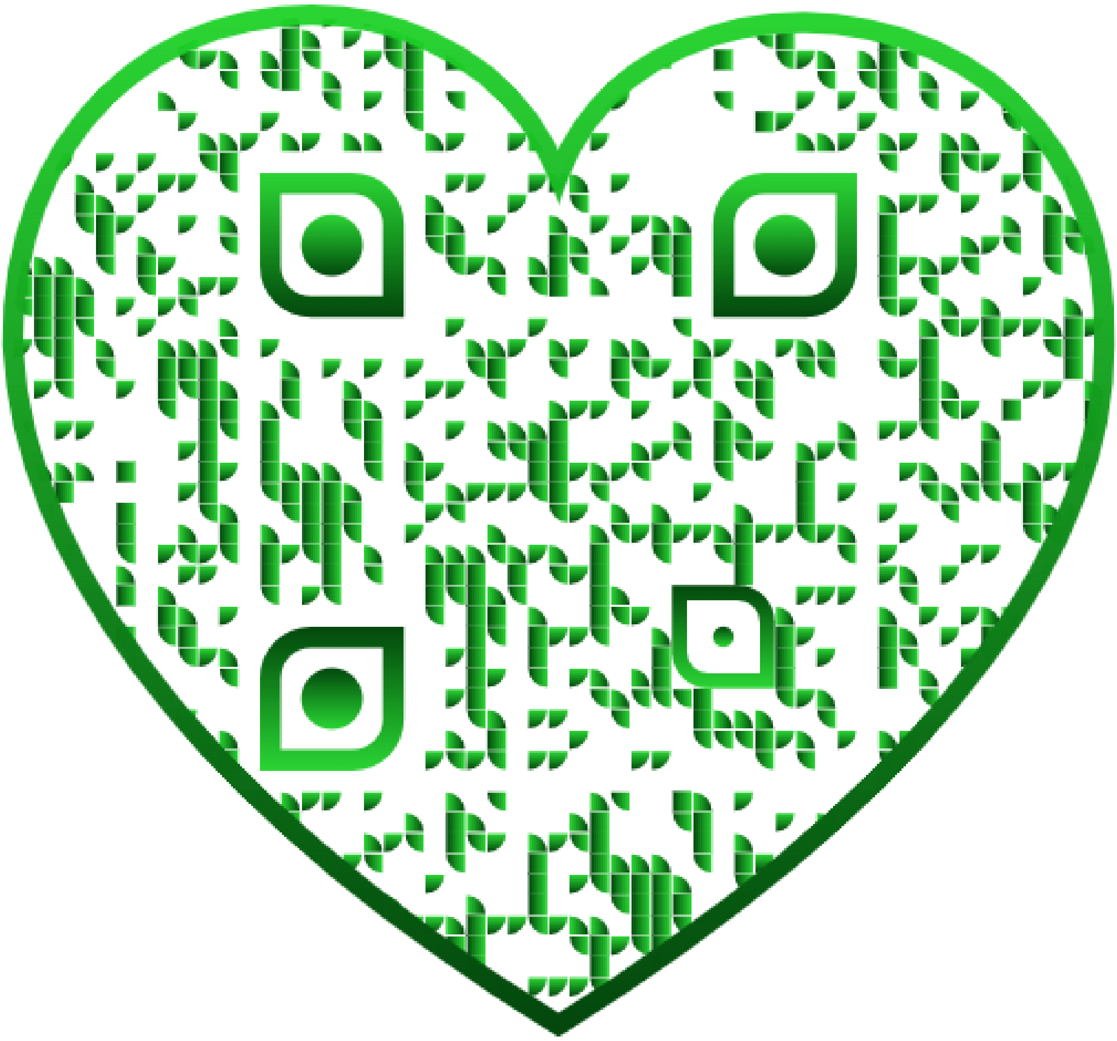

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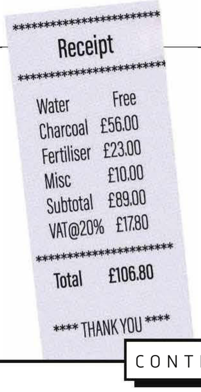

How much does a human being really cost? →p84

FROM THE EDITOR

Is there life elsewhere in the Universe? If you asked me, I'd say: we don't know, but I'd be astonished if there wasn't. If you look at the deep-field images taken by the James Webb Space Telescope, it's hard to think anything else. Those images capture a portion of the sky smaller than a grain of sand held at arm's length, and yet in them you can see thousands of galaxies.

Within each of the galaxies will be billions of stars. In the face of those odds, it just feels implausible – or maybe just sad – to think that our little rock is the only one where life found a way.

The more we study other-worldly materials, like meteorites from Mars and dust collected from asteroids, the more we find the type of ingredients needed for biological processes. The most compelling discovery of this kind came in January, when scientists declared they'd found 14 of the 20 amino acids that make up human proteins inside a sample returned from the asteroid Bennu.

In other words, we found more than half the ingredients for the molecules that make our cells function. In fact, they found all five of the nucleotide bases that make up our DNA (adenine, guanine, cytosine, thymine and uracil). Either we're incredibly lucky or the building blocks of life seem to be quite common.

So, what does it all mean? Could life be quite common in the cosmos? Did life on Earth come from another world? Jonathan O'Callaghan picks up the story on p62.

Daniel Bennett

Daniel Bennett, Editor

PS As this edition of *BBC Science Focus* was going to press, we learnt of the passing of Dr Stuart Farrimond. A friend of ours and a valued contributor to the magazine, he will be greatly missed.

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Curious Cases
Prof Hannah Fry and Dara Ó Briain ask scientists an age-old summertime question: Why do some people get bitten by mosquitoes more than others?
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TechXplore – Japan: From North to South
Tech reporter Paul Carter (above) travels to Japan's biggest innovation hubs to discover how technology is protecting the island nation's finite resources.
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BBC Inside Science: The mysteries of the ocean floor
New research claims that just 0.001 per cent of the world's deep seafloor has been seen by humans. Drs Katy Croff Bell (above) and Anna Gebruk discuss how we might see more.
Listen now on BBC Sounds

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JONATHAN O'CALLAGHAN

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DR JEANNINE BAUMGARTNER

Food scientist Jeannine reveals the surprising reasons why iron is the world's most common nutritional deficiency. →p31

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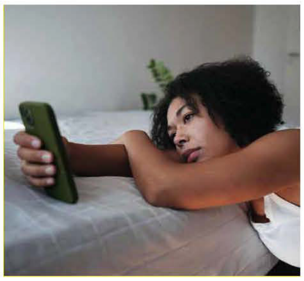

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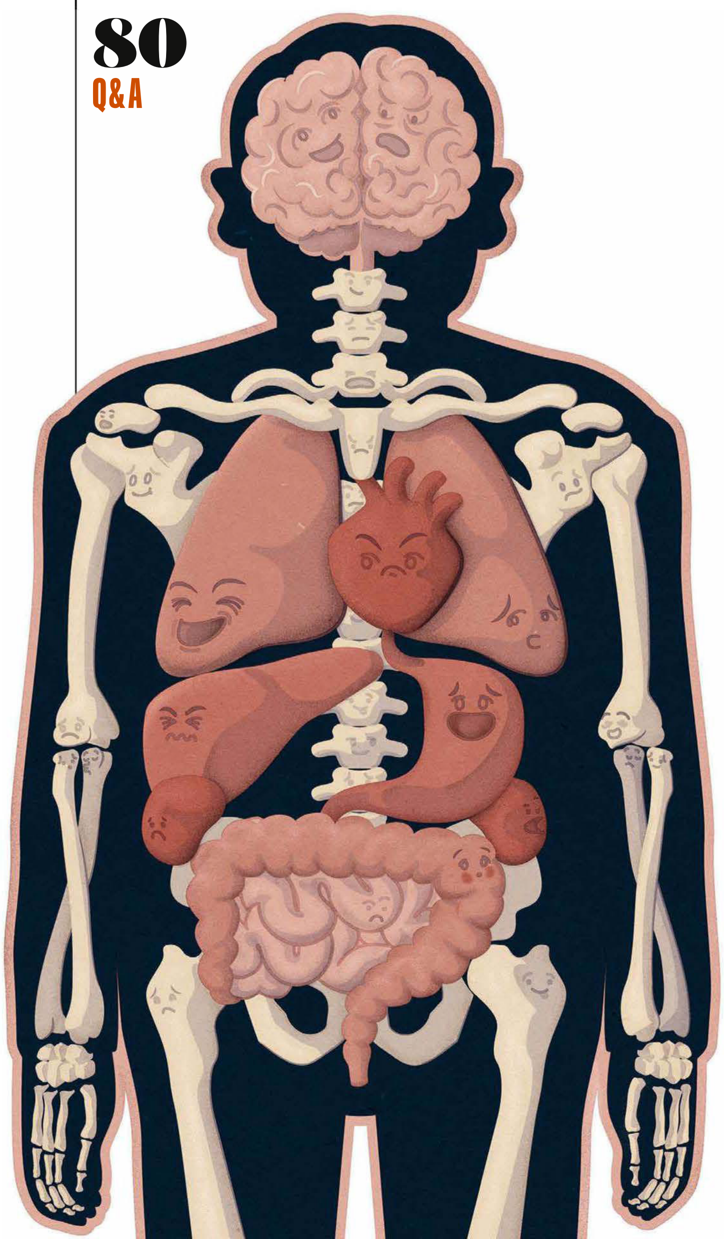

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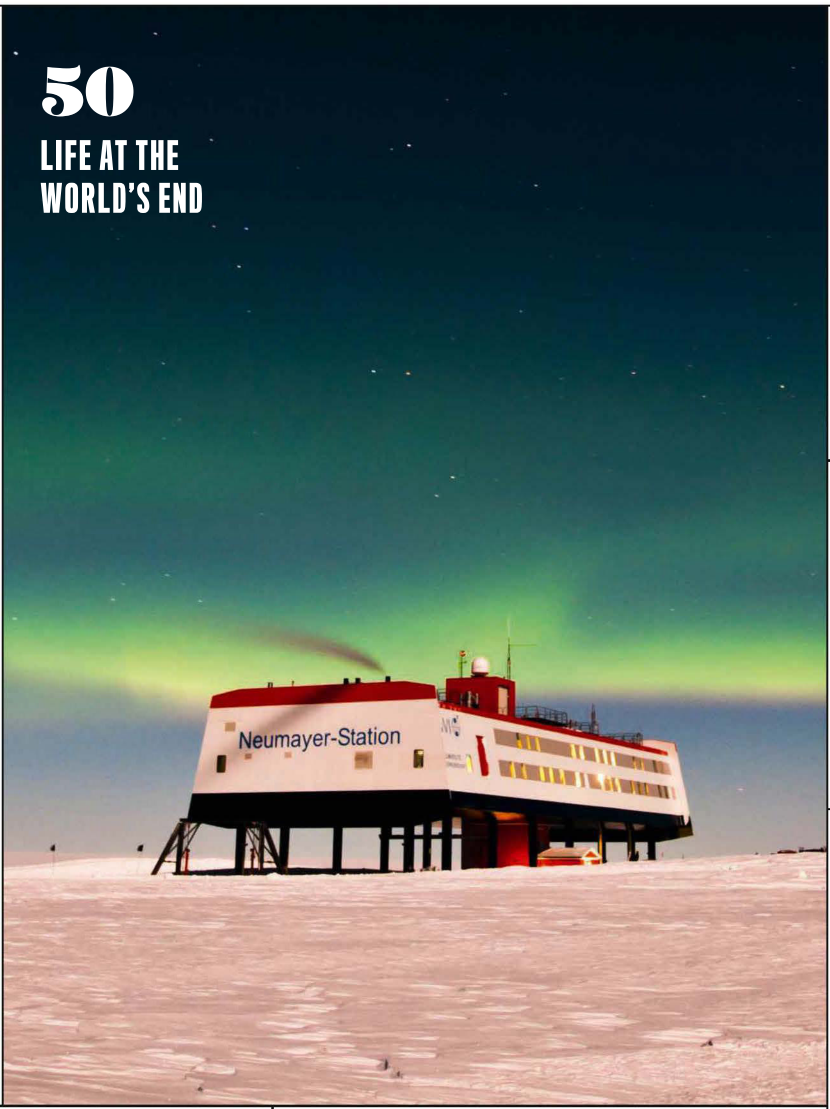

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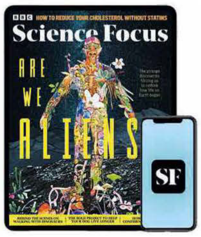

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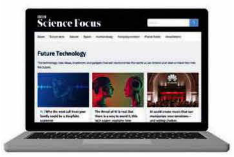

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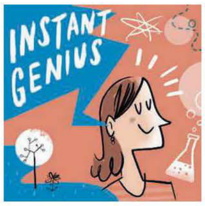

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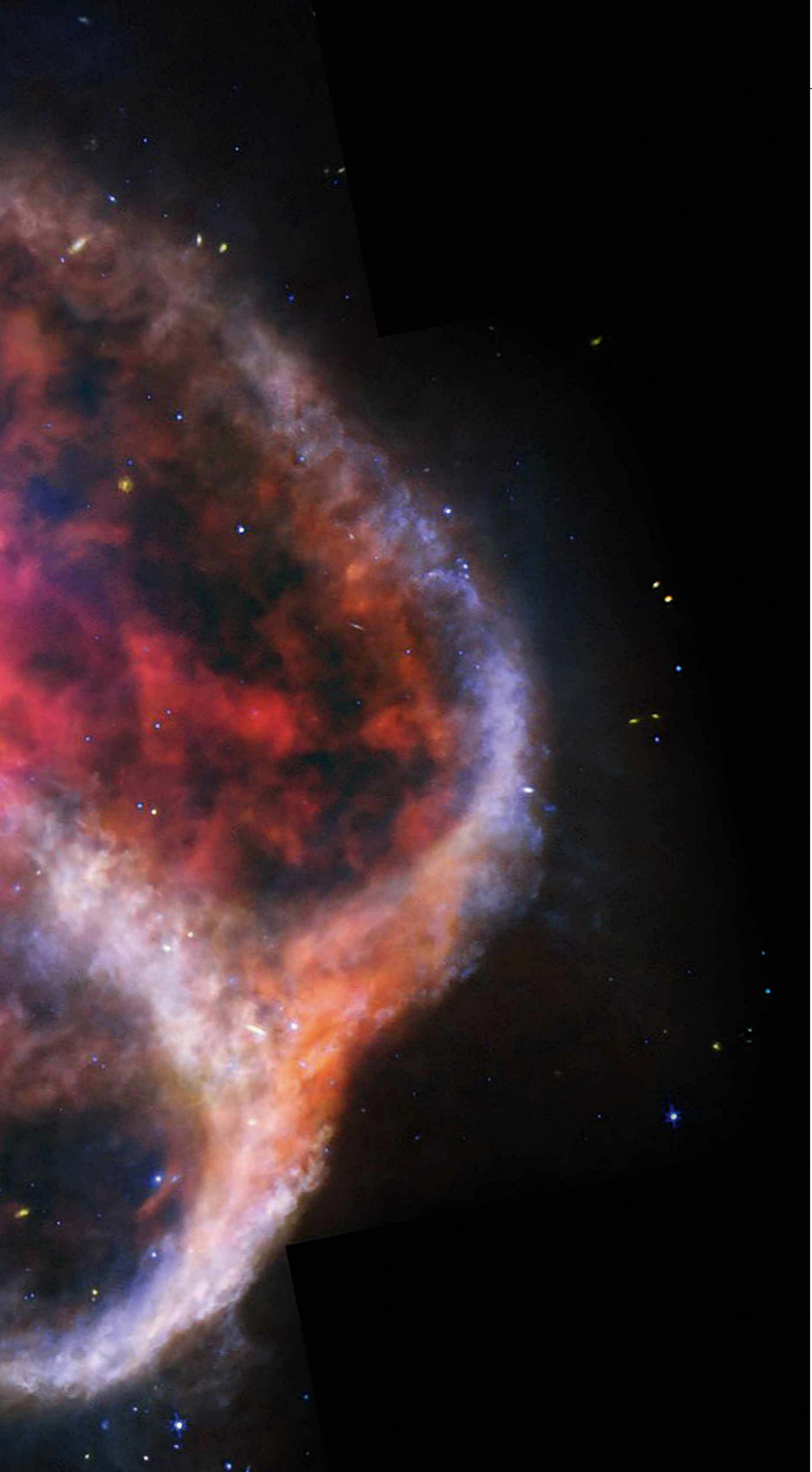

EYE OPENER

An eye for detail

No, this isn't a slice of cosmic bell pepper. It's actually the most detailed image taken to date of NGC 1514, a planetary nebula in the Taurus constellation approximately 1,500 light-years from Earth. Also known as the Crystal Ball Nebula, its two rings – one on top of the other – are formed from the gas and dust ejected by a dying star at the nebula's centre.

Invisible to the naked eye, the rings were first revealed in 2010 by NASA's Wide-field Infrared Survey Explorer (WISE) spacecraft. This new image, captured by the Mid-Infrared Instrument (MIRI) on the James Webb Space Telescope, provides a much clearer picture of the swirling clumps of material and the holes punched through the central pink region.

The jaw-dropping sight has been 4,000 years in the making – beginning when one of the two stars orbiting each other at the centre of the nebula exhausted the fuel powering its nuclear reaction. When that happened, it expelled its outer material to become a white dwarf. Over the subsequent millennia, the gravitational influence of its companion star formed the expelled material into the intricate object you see here.

NASA/ESA/CSA

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EYE OPENER

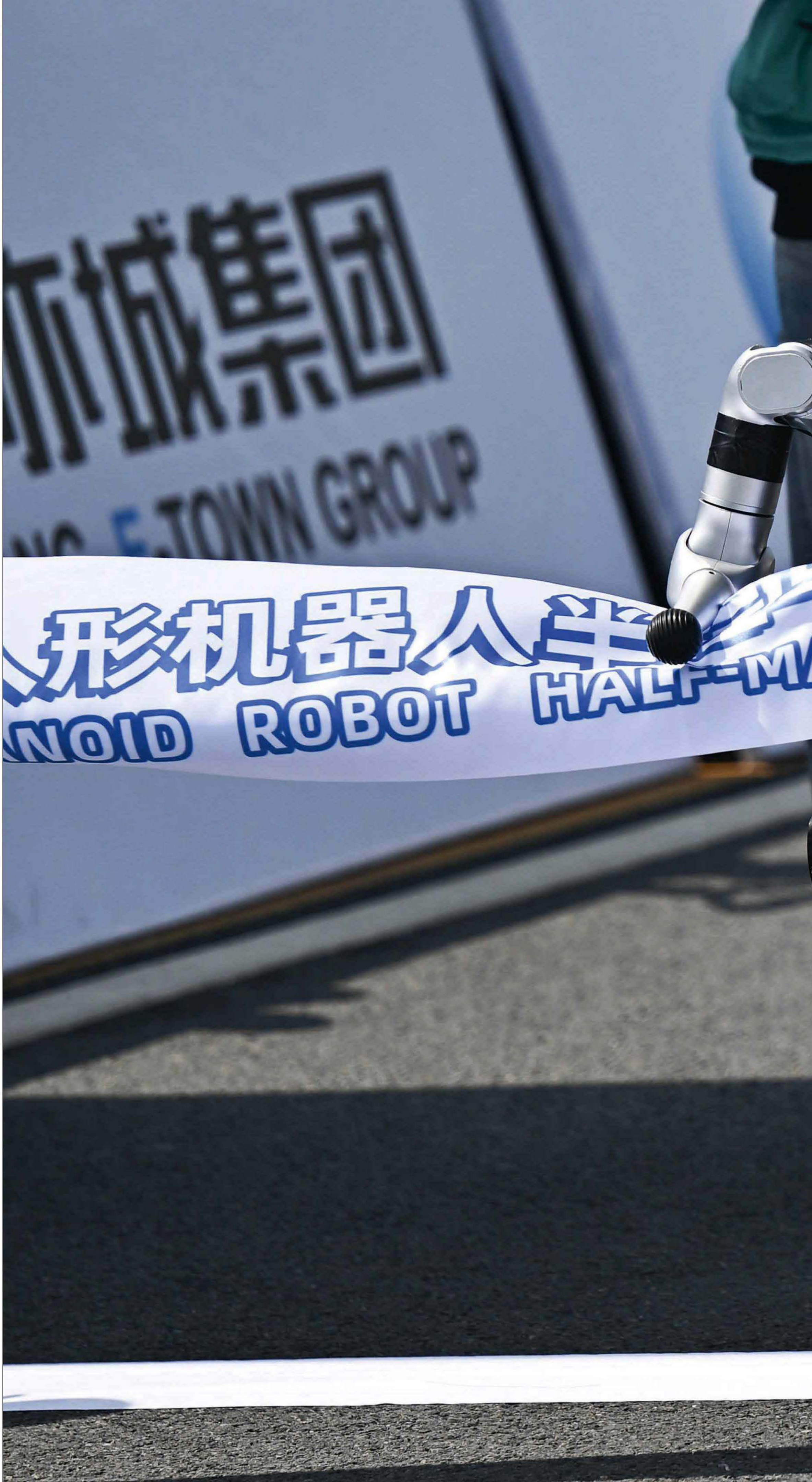
Usain Bot

BEIJING, **CHINA**

This image was captured at the finish line of the world's first human versus humanoid robot race. Staged in Beijing in April this year, it saw 21 robots compete alongside human runners over a 21km (13.1 mile) half-marathon course.

Running a half marathon is a challenging prospect for most people, but compared to their human counterparts, the robotic runners required a little more in the way of support. Not only did they have a dedicated running lane to themselves, each bot was also closely followed by its operators in case it fell and needed assistance getting back up, or needed a battery swap to make it to the end of the race. Some of the bots even had to be entirely replaced mid-race with a back-up bot (within the rules, but earning the replacement competitor a time penalty).

Of the 21 robots competing, just six managed to cross the finish line. The first to make it home was Tiangong Ultra from the Beijing Humanoid Robot Innovation Center with a time of 2:40:42 (and with three battery swaps). Hot on Tiangong Ultra's heels was Noetix's N2 bot (seen here breaking the tape) in 3:37:00. The flesh and blood runners were a little faster (for now, at least), with the first person crossing the line in 1:02:36.



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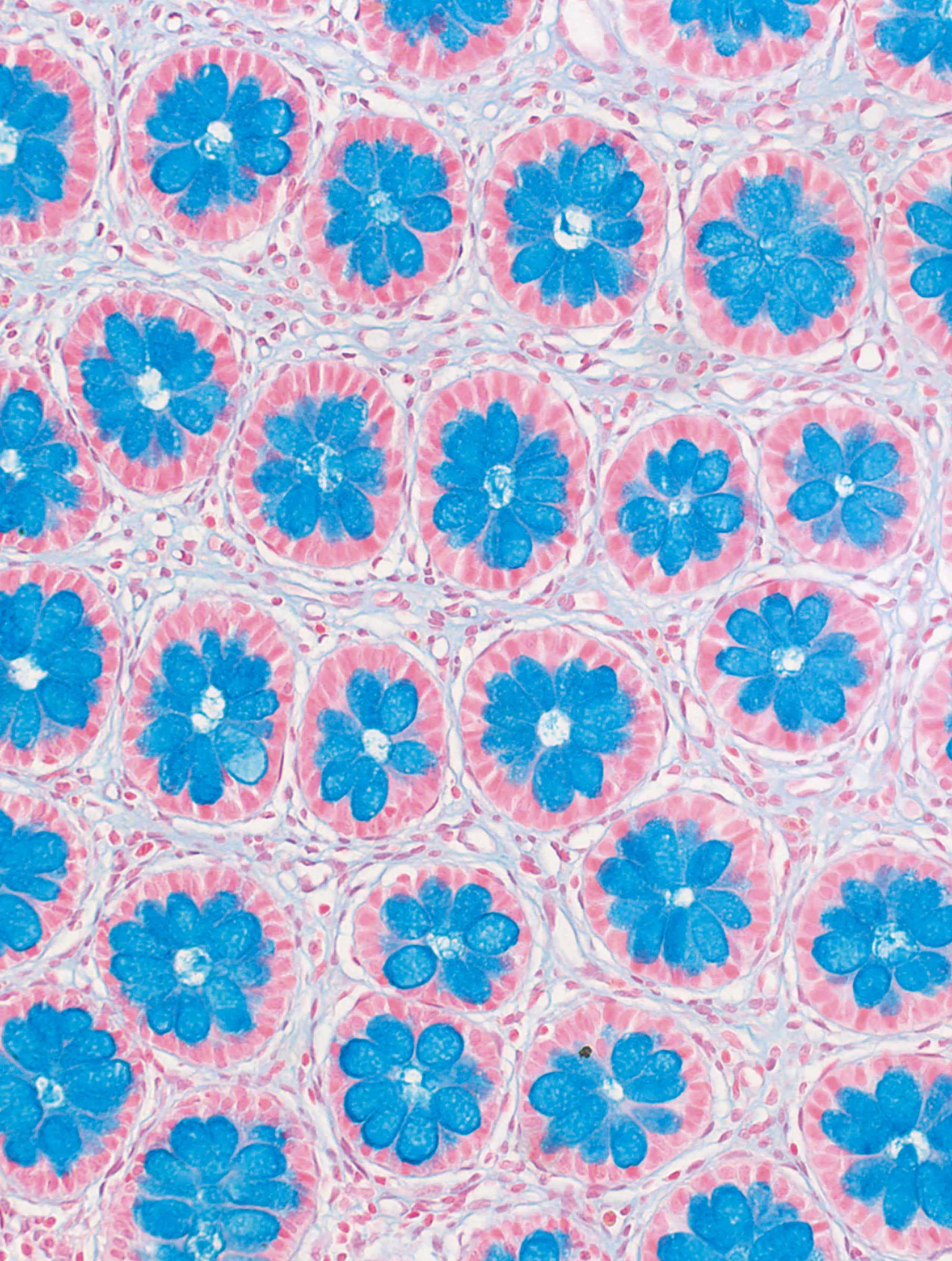

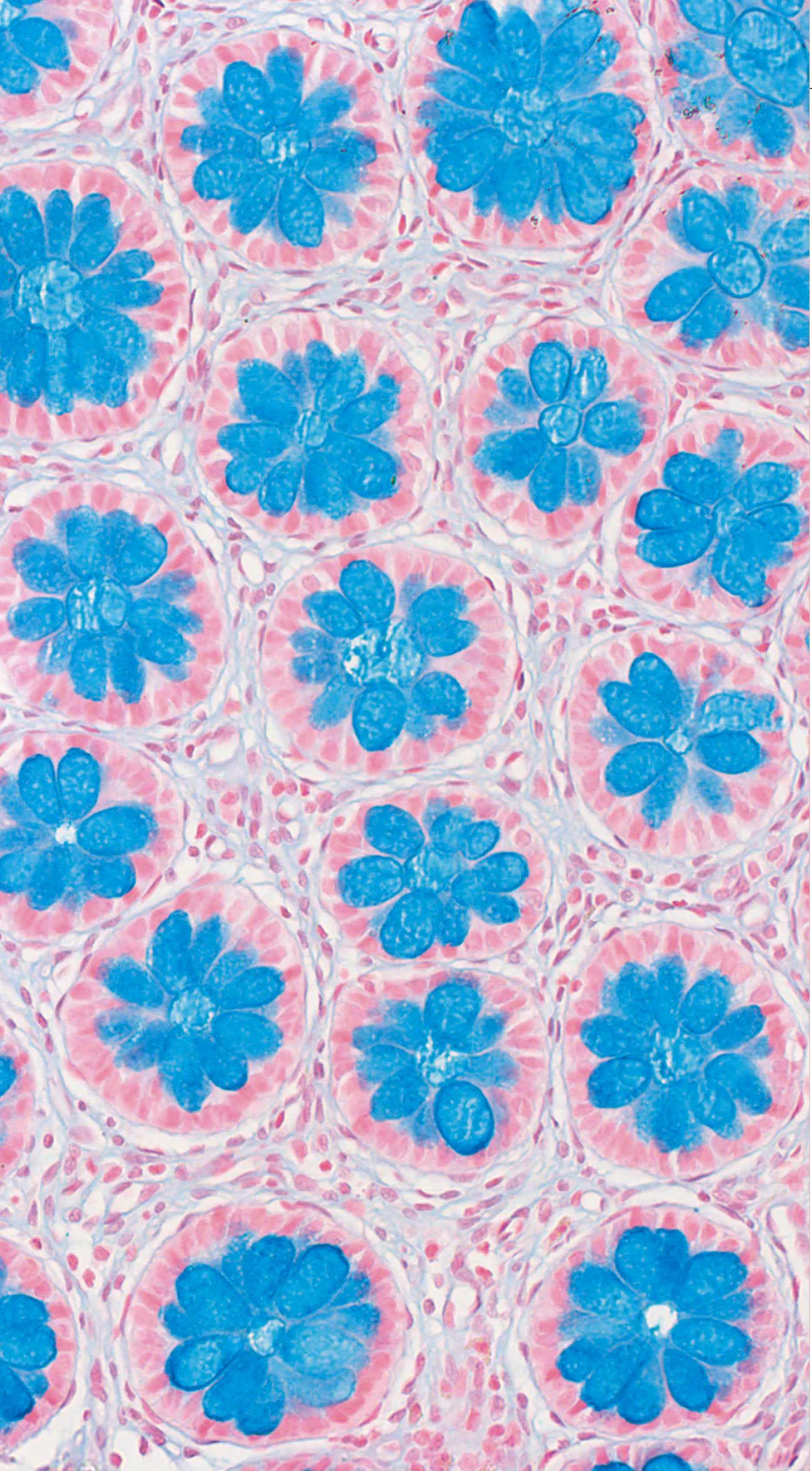

EYE OPENER

Bowel in bloom

LONDON, **UK**

What, at first glance, appears to be a field of blue daisies is actually the protective lining of the human colon. When a sample is stained and viewed under a microscope, colonic crypts – deep pockets in the tissue lining – appear as these 'flowers'. Each 'flower' contains specialised cells that produce a protective layer of mucus, which both prevents rogue organisms from harming the colon and helps it absorb nutrients.

This sample was taken from a patient with Hirschsprung's disease, a rare bowel condition where children are born with some of the nerve cells missing in their large intestine. This breaks the protective mucus barrier, leaving the colon vulnerable to tissue damage and inflammation.

The picture won this year's National Institute for Health and Care Research Great Ormond Street Hospital (GOSH) Biomedical Research Centre image competition. It was taken by Lucy Holland, a PhD student studying Hirschsprung's disease at GOSH.

"While capturing my image, I was struck by how such a clinically important tissue sample could also be so beautiful," she said. "It reminded me that behind every biological sample and every data point, there's a patient placing their trust and hope into our research."

LUCY HOLLAND/ GREAT ORMOND STREET

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locommotion?

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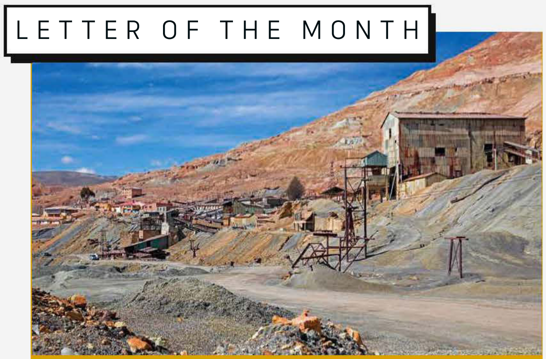
LETTER OF THE MONTH



A silver mine in Cerro Rico de Potosi, Bolivia

Alien archaeology

The 'Silurian' hypothesis – the idea that aliens have already been to Earth – was mentioned in your April Q&A section (p84) by Dr Claire Asher. American science-fiction writer Keith Laumer suggested there might be some evidence for this theory.

He argued that as so many of the materials that we consider "precious" – gold, silver, platinum – turn out to have important technological uses – lasers, microcircuitry, etc. – they could have been left here by aliens for us to use.

Similarly, humanity might leave something behind for aliens to discover. We've advanced to the point where evidence of our existence extends beyond Earth – on the Moon, Mars and in various orbits and trajectories. These objects won't be subject to the same processes of erosion as on our planet, and will possibly exist for millions of years.

Of course, whatever evidence of our existence we leave behind is only significant if someone emerges to rediscover it…

Peter Davey, Bournemouth

WRITE IN!

The writer of next issue's Letter of the Month receives a pair of popular science books: **Soviets in Space** *and* **Mars**.

WORTH OVER £45

SOVIETS IN SPACE
MARS

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Nailed it

I agree with Dr Justin O Schmidt (April, p87) – the "pure, intense, brilliant pain" he described was my exact experience when getting bitten by a fire ant (below). It felt like a very hot nail was being stabbed into my back. Within an hour, there was a small white bump that reached the size of a nickel. It took three weeks for it to be absorbed and gone.

Barb Cobb, via email

Statin studies

Thank you for Hayley Bennett's article 'Are statins the best way to lower my cholesterol?' (April, p76). In it, she mentioned the "hundreds of studies" done to confirm that statins are safe. Were some of those done on women, not just men?

SLF, New York

Hayley Bennett replies… *"In the past, statins and other medical treatments weren't well tested in women. However, scientists have been working hard to change this.*

A 2015 study in The Lancet, *for example, brought together data from 27 clinical trials involving 50,000 women (out of 170,000 test subjects total) to show statins benefit women as much as men.*

That's not to say that there aren't differences between the sexes. For example, women's risk of heart disease tends to increase sharply during menopause, so cholesterol monitoring and treatment can become even more important."

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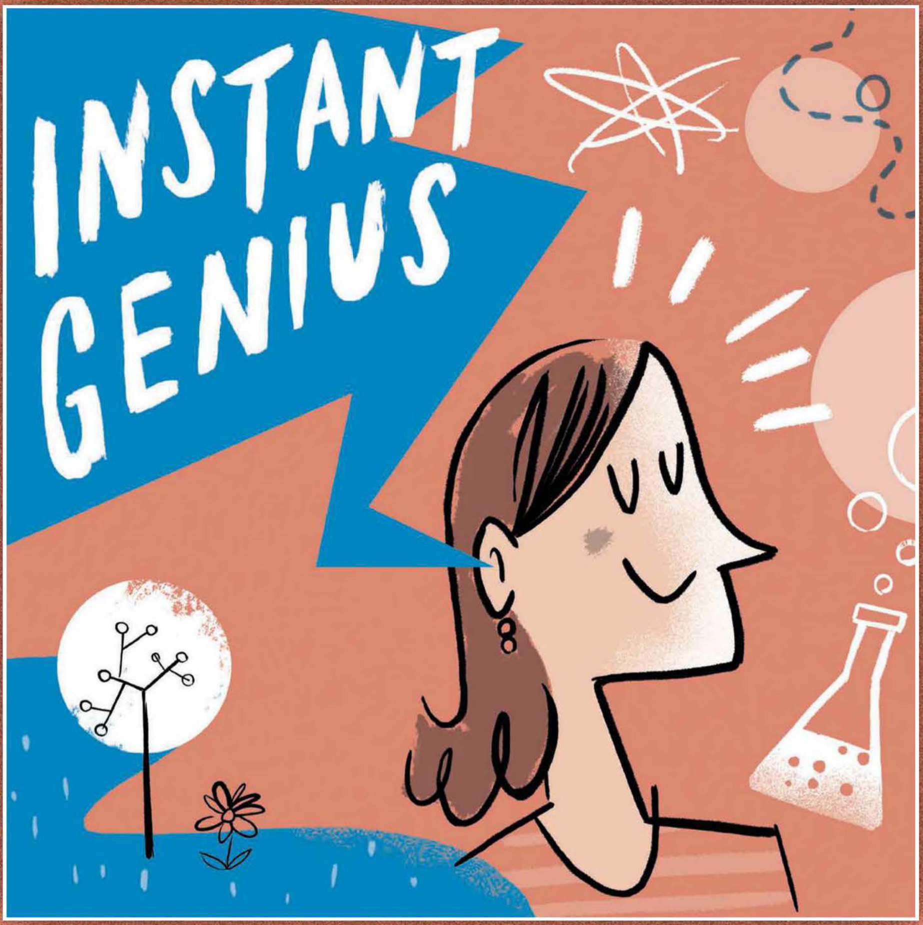

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RUBY WRIGHT

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BONE TO STICK
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NEWS FROM THE FRONTIERS OF SCIENCE

DISCOVERIES

SPACE

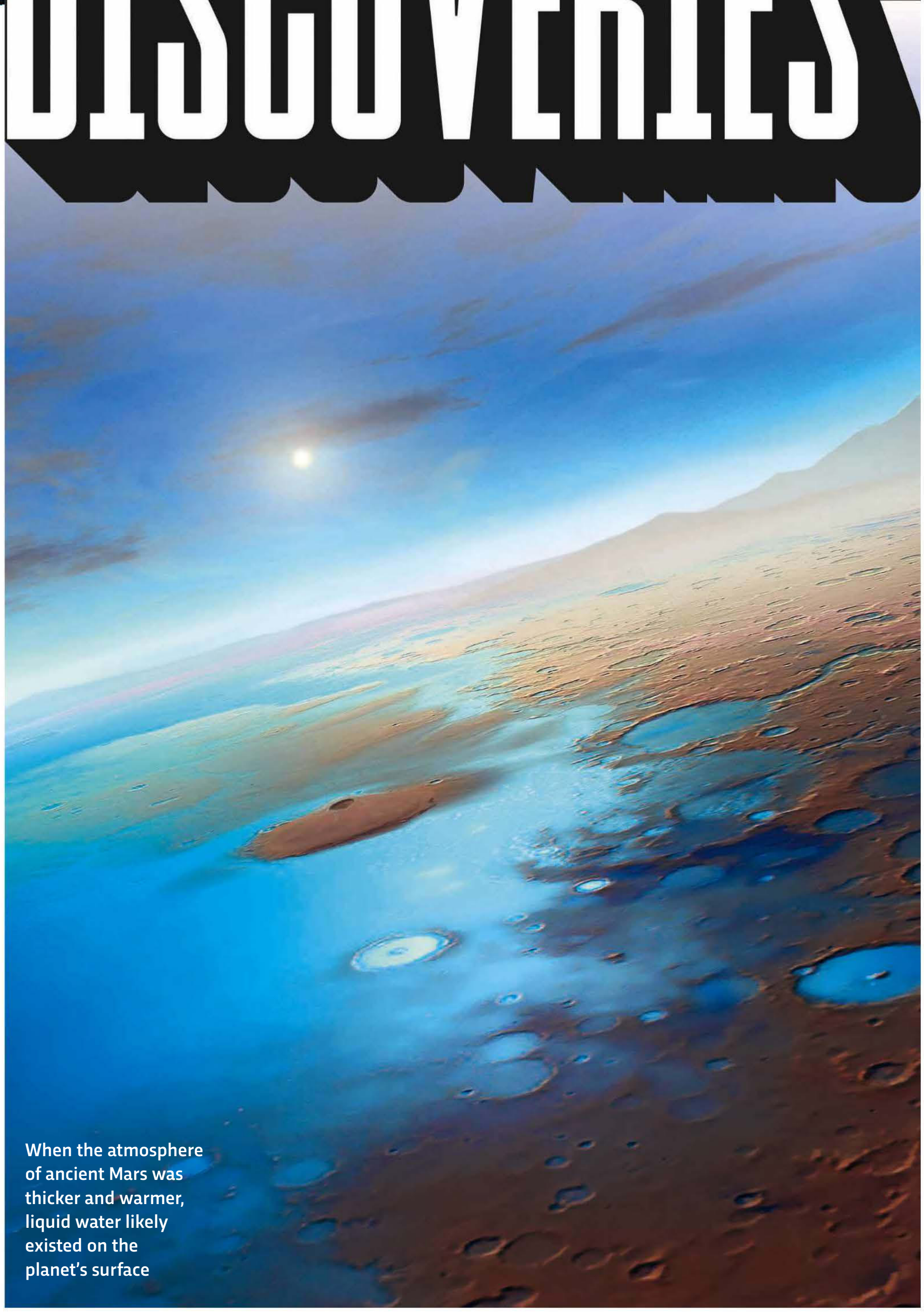
Scientists find vast ocean of liquid water on Mars

A new study may have uncovered the Red Planet's long-lost water – and a fresh lead in the search for life

Mars once had vast oceans on its surface. Then its magnetic field weakened, its atmosphere thinned, and its water vanished. But the numbers don't add up. For the Red Planet to have transformed from a watery world into the red dust bowl we know today, all that water had to end up somewhere. So, where did it go?

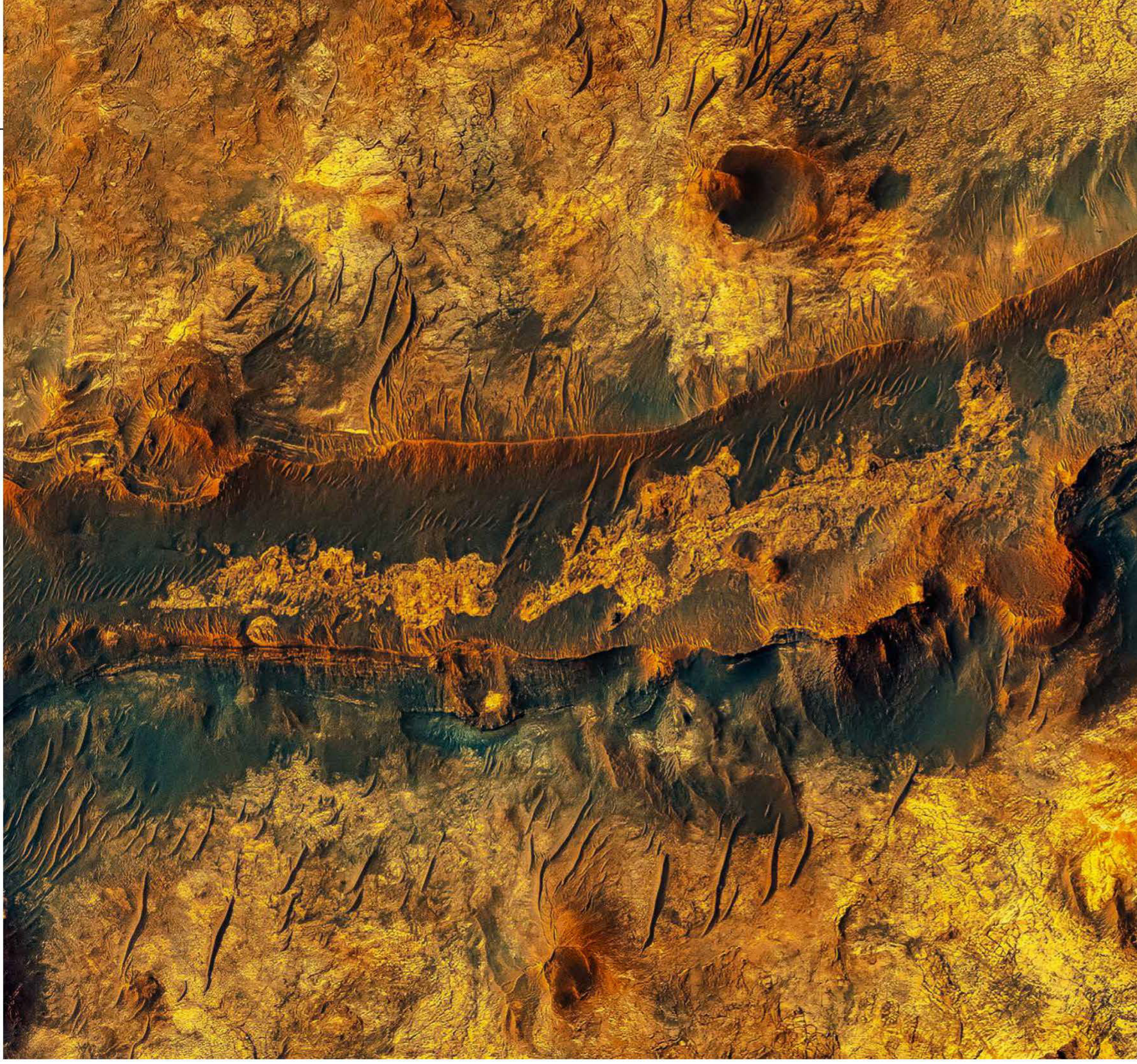
A new study published in the *National Science Review* may finally have an answer, as a research team from China, Australia and Italy have identified a vast reservoir of water that may lie deep beneath the planet's surface. What's more, unlike possible icy reservoirs found on other parts of Mars, this water is thought to still be in its liquid form, making it one of the best bets yet that extraterrestrial life exists.

Around four billion years ago, much of the Martian surface was covered in liquid water. If spread evenly across the planet, this water would have formed a global ocean



When the atmosphere of ancient Mars was thicker and warmer, liquid water likely existed on the planet's surface

MARK GARLICK/SCIENCE PHOTO LIBRARY/GETTY IMAGES, ADAM GALE X3



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1,500m (4,920ft) deep – a figure known as the global equivalent layer (GEL). That's about the same amount of water as held in Earth's Indian Ocean today.

While there's still debate over the exact amounts, this estimate leaves a glaring discrepancy.

"The estimated volumes of liquid water lost to space and through crustal hydration were 10–200m (33–656ft) GEL and 550m (1,800ft) GEL, respectively," Weijia Sun, a professor of geophysics at the Chinese Academy of Sciences and first author of the new study, told *BBC Science Focus.*

"The present-day water inventory in Mars's atmosphere and the ice in its polar regions or subsurface ice totals 20–40m (66–131ft) GEL."

That leaves between 710–920m (2,330–3,020ft) GEL unaccounted for: the "missing water" of Mars, as Sun and his colleagues put it.

MARSQUAKES AND METEORITES

When NASA's InSight lander touched down on the surface of Mars on 26 November 2018, it opened a new window into the subsurface. On board was a small, round dome containing a seismometer – the same devices that measure earthquakes on Earth – designed, in NASA's words, to take the planet's 'pulse'.

In the new study, the team measured seismic waves travelling through the planet from two meteorite impacts and one 'marsquake'. Speaking to *BBC Science Focus*, study co-author Prof Hrvoje Tkalčić likened this technique to using ultrasounds to see inside a patient's body.

"In a nutshell, seismic waves spreading through the planet's interior from distant events enter the crustal layers beneath the receiver," Tkalčić said. "And we infer the thicknesses of these layers and the depth of the boundaries from mapping their reverberations."

Seismic waves travel faster through dry rock than through rock saturated with water. Therefore, by measuring the wave speeds from the impacts and quakes, scientists can detect water deep underground without needing to drill into it.

> **"Identifying locations with liquid water on Mars is a key strategy in the search for potential life"**

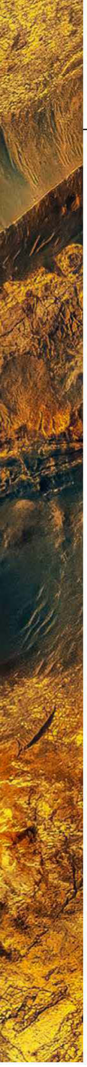
This state-of-the-art technique – known as 'receiver functions' – allowed the team to detect a layer around 5.4–8km (3.4–5 miles) below the Martian surface where seismic waves are slowing down in just the right way to signal the presence of water. At such a depth, the temperature is high enough for the water to exist as a liquid. And, crucially, the amount of water down there was estimated by the researchers to be between 520–780m (1,700–2,560ft) GEL – coinciding neatly with the 710–920m (2,330–3,020ft) GEL of 'missing water'.

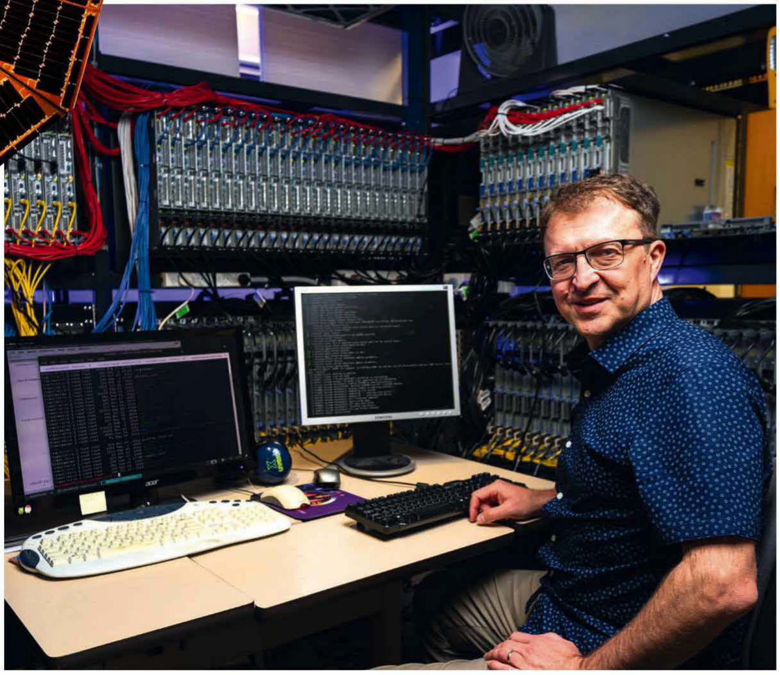
LIFE ON MARS?

If a giant aquifer does exist beneath the surface of Mars, it would make for a good place to hunt for extraterrestrial life. After all, water is *the* key ingredient for life on Earth, and deep subterranean life (especially bacteria and similar microorganisms known as archaea) is so significant on our planet that it accounts for around 15 per cent of Earth's total biomass.

We're unlikely to find flora or fauna at such depths on Mars – but microbial life? That remains a possibility.

"The presence of liquid water is regarded as one of the most critical factors in this endeavour,





ABOVE LEFT Ancient rivers in Mawrth Vallis, one of the oldest valleys on Mars

ABOVE The InSight Lander with its twin solar arrays deployed

RIGHT Professor Hrvoje Tkalčić

as it is a fundamental prerequisite for life as we know it," Tkalčić said. "Consequently, identifying locations with liquid water on Mars is a key strategy in the search for potential life."

Moreover, as we look to establish human settlements on Mars, water will be an essential resource. Drilling kilometres beneath the surface would be a formidable engineering feat, but – when it comes to building a home on another planet – such challenges are necessary.

But before you start saving for your ticket to Mars, Tkalčić and Sun emphasise that the presence of the aquifer isn't a certainty just yet. Working with such a limited dataset, they say more information is needed before conclusions are drawn.

While liquid water is the most likely explanation based on available data, there are other plausible explanations for the seismic waves slowing down, like the presence of an additional layer of sediment.

Here on Earth, seismological measurements are carried out using scores of seismometers across the globe, with multiple data points helping to verify one another. On Mars, it's a different story.

"We should always keep in mind that we are dealing with the data from a single seismometer on a distant planet. That's a very prohibitive observational environment, and we're doing the best we can given the quality and quantity of data we have," said Tkalčić.

The researchers are hopeful that future Mars missions equipped with more seismometers will allow us to probe a larger portion of the planet in greater detail. In time, we may even be able to drill into the crust itself – analysing its chemistry for direct evidence of water, and perhaps even signs of life.

For now, the study is a promising glimpse of what future missions might uncover.

As Sun put it: "These findings provide critical insights into the Martian water cycle and the evolution of its habitable environments, laying a crucial foundation for future research on the search for Martian life and the planet's climate history."

HEALTH

The eight-hour sleep rule is outdated, says major study

It's likely that there's no 'ideal' number of sleeping hours for optimum health, experts now say – instead, it probably varies by country

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PETER DAZELEY/GETTY IMAGES

> **"What's considered 'enough' sleep in one country might feel like too much or not enough in another"**

It doesn't matter whether you get eight hours of sleep or six and a half – as long as that's normal for where you live. At least, that's according to a new study by researchers at the University of Victoria and the University of British Columbia, in Canada.

The paper argues that cultural norms shape your sleep needs, so recommendations should be tailored to each country rather than following a universal eight-hour rule.

"Sleep is shaped by more than just biology – it's influenced by culture, work schedules, climate, light exposure, social norms and other factors," lead author Dr Christine Ou, an assistant professor at Victoria's School of Nursing, told *BBC Science Focus*. "What's considered 'enough' sleep in one country might feel like too much or not enough in another."

Ou's team analysed sleep habits and health data from nearly 5,000 people who completed an online questionnaire in 20 different countries across North America, South America, Europe, Asia and Africa.

Using this alongside additional data from 14 previous studies, the scientists analysed whether life expectancy and rates of heart disease, obesity and diabetes were linked to how long people slept.

They discovered that the amount of sleep the participants were getting varied widely across the 20 countries. At the top were the French participants, who slept for an average of seven hours and 52 minutes the night before filling out the questionnaire. The shortest sleepers were found in Japan, where participants had slept an average of just six hours and 18 minutes.

The worldwide average was seven hours and 15 minutes. In the UK, respondents slept for seven hours and 33 minutes; in the US, for seven hours and two minutes.

Ou's team also made a surprising discovery: there was no 'ideal' amount of sleep across all the countries that led to good health. In other words, her team found no evidence that people in countries with shorter average sleep durations had worse health than individuals in countries where people slept for longer each night.

One answer was common across the board, though.

Participants were asked what they thought the optimum number of sleep hours for good health was. In Costa Rica, for example, this averaged at eight hours and three minutes, whereas it was just seven hours and 16 minutes in South Korea. In every country, most people felt they were between one hour and an hour and 40 minutes short of this target.

Yet those whose sleeping hours were closest to their country's optimum were most likely to be in good health.

"Our study found that people tend to be healthier when their sleep aligns with what's typical in their culture," said Ou. "Recognising cultural context can help people focus on what actually supports their health, rather than chasing a fixed number."

Within each country, the scientists found that deviating too much from the cultural sleep norm was associated with worse health outcomes, whether that meant getting too much or too little sleep.

The point at which too much sleep started to lead to worse health outcomes also varied. This point was highest in the UK, where participants getting over 10 hours and 26 minutes of sleep started to lose the health benefits of getting enough sleep.

The lowest was in the US, where participants could only slumber for eight hours and 13 minutes before this started to happen.

Sleep psychologist Dr Daljinder Chalmers, of Keele University, told *BBC Science Focus*: "Sleep is really complex, and there's no evidence to support the idea that we should all sleep for eight hours per day."

Chalmers, who wasn't involved with this research, added that in countries where people sleep less during the night, it's difficult to differentiate between whether they feel the need to nap more during the day, or whether they just need less sleep in general. In Japan, for example, some people adopt a 'hirune' – a lunchtime sleep – into their daily routine.

She said, "When you're looking at sleep and health, you need to consider culture."

The researchers behind the study controlled for factors like the nutrition, wealth, inequality and geography of each country – but this was still only an observational study, so they couldn't make conclusions about the direct effect that sleep had on the participants' health.

Sleep statistics

Worldwide average:

7h15

Countries involved in the study: mean average for last night's sleep

France: 7h52
Netherlands: 7h46
Belgium: 7h41
New Zealand: 7h40
United Kingdom: 7h33
South Africa: 7h31
Australia: 7h29
Canada: 7h27
China: 7h18
India: 7h15
Argentina: 7h14
Costa Rica: 7h11
Spain: 7h11
Colombia: 7h11
Mexico: 7h04
United States: 7h02
Singapore: 6h59
South Korea: 6h45
Taiwan: 6h40
Japan: 6h18

ARCHAEOLOGY

Skeleton confirms that gladiators fought lions

Bite marks reveal the gruesome death of a gladiator

Archaeologists uncovered the first physical evidence of Roman gladiators fighting lions after bite marks on a skeleton excavated in York, England, were identified as those of a lion.

The remains, found alongside 80 other male skeletons at Driffield Terrace – one of the best-preserved gladiator cemeteries in the Roman world – belong to a man who died around 1,800 years ago.

In a new analysis of the skeleton, the research team took 3D scans of the tooth marks and compared them to sample bites from a lion at a zoo. It was a match.

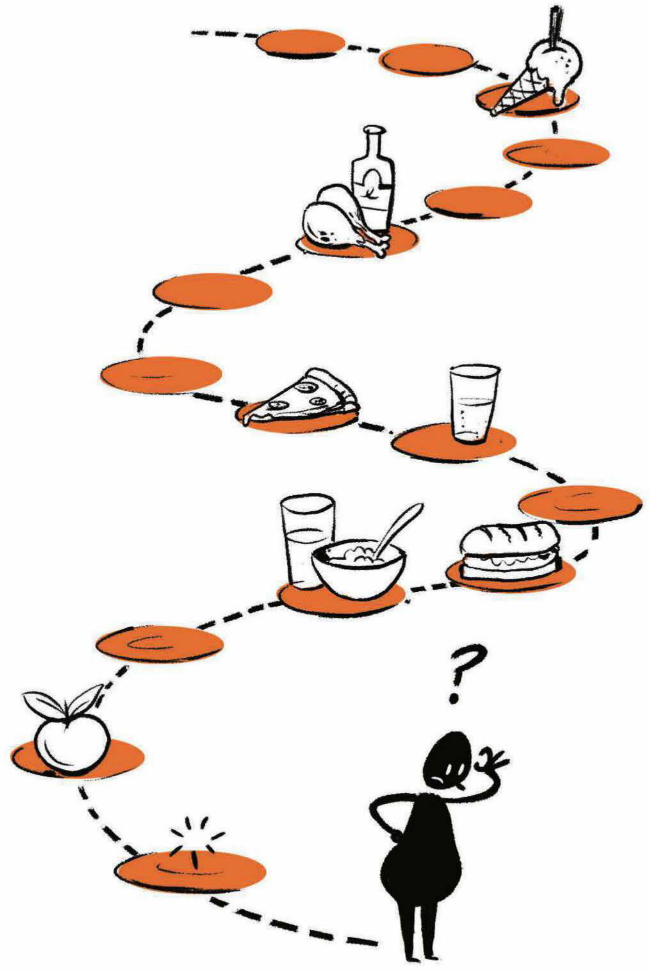
“This is a hugely exciting find,” said Malin Holst, lecturer in osteoarchaeology at the University of York. “We can now start to build a better image of what these gladiators were like in life, and it also confirms the presence of large cats, and potentially other exotic animals, in arenas in cities such as York, and how they too had to defend themselves from the threat of death.”

After death by lion bite, the man appears to have been decapitated – a practice observed in Roman burials. He also showed signs of spinal damage, inflammation and physical strain, possibly from intense fight training.

Signs of violent injury point to this man being a gladiator. Specifically, a bestiarius: a type of fighter who faced wild animals, and often hailed from a slave background.

“For years, our understanding of Roman gladiatorial combat and animal spectacles has relied heavily on historical texts and artistic depictions,” said study author Prof Tim Thompson of Maynooth University, in Ireland. “This discovery provides the first direct, physical evidence that such events took place in this period, reshaping our perception of Roman entertainment culture in the region.”

Although an amphitheatre is yet to be found in York, historical evidence suggests that the city hosted a plethora of arena events well into the fourth century AD.



HEALTH

The surprising way your body fat sabotages intermittent fasting

A study in mice reveals that obesity could change how our bodies respond to periods of fasting

Intermittent fasting has become a popular strategy for boosting metabolism. Now, a new study suggests that its benefits may be blunted by body fat. The likely cause? An obese liver’s inability to adapt to starvation.

ILLUSTRATIONS: ADAM GALE

Intermittent fasting involves prolonged periods of calorie restriction followed by windows of normal eating. For the study, published in *Science Signaling*, the researchers monitored changes in the livers of healthy mice and obese mice lacking leptin – a hormone that regulates appetite – during periods of food deprivation.

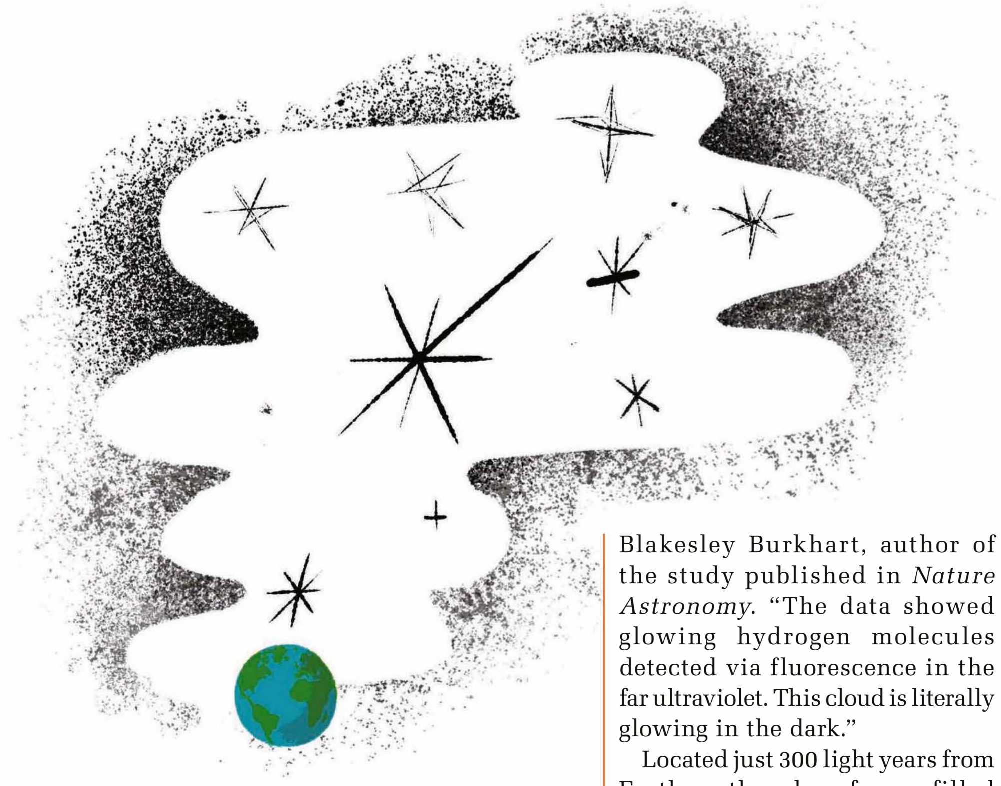
A healthy liver responds to starvation by rapidly releasing chemical compounds – like adenosine triphosphate (ATP) and adenosine monophosphate (AMP) – to regulate metabolic reactions to conserve and redistribute energy. The researchers discovered that in mice with obesity this process, though operational, was sluggish and disorganised.

When ATP and AMP react quickly to a lack of food, they help the liver switch from storing energy to burning it. It’s this shift that’s thought to drive many of the benefits from intermittent fasting, such as weight loss and improved blood sugar control.

“This process appears to be disrupted in obesity,” co-lead author Prof Shinya Kuroda told *BBC Science Focus*.

Instead, obesity introduces a kind of metabolic ‘jet lag’, the researchers say, who think the findings could help to inform targeted therapeutics for people with obesity.

> **“When ATP and AMP react quickly to a lack of food, they help the liver switch from storing energy to burning it”**



SPACE

Massive star-forming cloud found strangely close to Earth

New methods detected a previously concealed megastructure in space

An enormous cloud of hydrogen gas – one of the largest single structures ever observed in the sky – has been discovered surprisingly close to Earth.

Named Eos after the Greek goddess of the dawn, the cloud was detected because of its faint far-ultraviolet light, which is naturally emitted by hydrogen molecules. Known as molecular clouds, these enormous structures of gas and dust are the cradles where new stars are born.

“This is the first-ever molecular cloud discovered by looking for far-ultraviolet emission of molecular hydrogen directly,” said Prof Blakesley Burkhart, author of the study published in *Nature Astronomy*. “The data showed glowing hydrogen molecules detected via fluorescence in the far ultraviolet. This cloud is literally glowing in the dark.”

Located just 300 light years from Earth on the edge of a gas-filled region known as the Local Bubble, Eos stretches across a patch of sky equivalent to the width of 40 full Moons and has a mass about 3,400 times greater than the Sun.

Despite its size and proximity to us, it had remained hidden due to being ‘CO-dark’ – in other words, it lacked enough carbon monoxide to show up using conventional detection methods.

“The discovery of Eos is exciting because we can now directly measure how molecular clouds are forming and dissociating, and how a galaxy begins to transform interstellar gas and dust into stars and planets,” Burkhart said.

The data came from a far-ultraviolet spectrograph aboard the Korean satellite STSat-1. The dataset was publicly released in 2023 – Burkhart spotted the hidden structure soon after.

“The story of the cosmos is a story of the rearrangement of atoms over billions of years,” Burkhart said. “The hydrogen that’s currently in the Eos cloud existed at the time of the Big Bang and eventually fell onto our galaxy and coalesced nearby to the Sun. So, it’s been a long journey of 13.6 billion years for these hydrogen atoms.”

GEOLOGY

‘Zombie’ volcano might not be so dead after all

This sleeping giant has plenty going on beneath the surface. Should we be worried?

“Researchers have observed unusual activity, including small earthquakes“

A huge ‘zombie’ volcano in Bolivia is showing signs of life, but thankfully scientists say that there’s little immediate risk of an eruption.

Uturuncu, a towering peak in the Central Andes, last erupted around 250,000 years ago. Yet for decades, researchers have observed unusual activity, including small earthquakes and a distinctive ‘sombrero’ pattern of ground deformation – the centre of the volcano is slowly rising, while the surrounding area sinks.

Until now, the cause of this unrest remained unclear. But a new study published in the journal *PNAS* reveals that heated liquids and gases are still migrating beneath Uturuncu, creating pockets of pressure that deform the surface.

The international team of researchers from China, the UK and the US used seismic data from more than 1,700 earthquakes to produce the most detailed three-dimensional image of the volcano’s underground structure to date. The fluids, they say, are rising from a vast reservoir of magma buried deep beneath the Andes.

As they rise, they form pockets of gas and brine just below the volcano’s summit. Crucially, though, these gas pockets don’t appear to be big enough to cause a major eruption.

The scientists say that their research method could be applied to over a thousand other zombie volcanoes, revealing whether signs of movement in officially dormant volcanoes are actually worrisome warning signs of a geological force coming back to life.

HEALTH

Deadly peanut allergies could be prevented with a simple new method

Adults with severe peanut allergies were trained to tolerate handfuls of peanuts in a new study

A new study offers hope to adults who live in fear of their allergic reactions, as adults with severe peanut allergies could become tolerant in a matter of weeks.

The research, published in the journal *Allergy*, shows that scientists were able to gradually introduce severely allergic adults to peanut products and peanuts in increasing amounts. By the end of the trial, 14 out of 21 of the adults were able to tolerate a whole handful of peanuts without an allergic reaction.

Gradual exposure to allergens – otherwise known as oral immunotherapy – has been successful in previous trials on children and babies, but this is the first time it’s been tested on adults. Chief Investigator Prof Stephen Till, an

ILLUSTRATIONS: ADAM GALE

NATURE

New 'Bone Collector' caterpillar wears the remains of its prey

The species has a grotesque fashion sense, to say the least

A newly-discovered species of caterpillar has been found creeping through spider webs on the Hawaiian island of O'ahu – and it's unlike anything scientists have seen before. This caterpillar is carnivorous – and, after it's finished feasting on its prey, it wears their body parts as camouflage.

Dubbed the 'Bone Collector' by the researchers who found it, the bizarre insect is a rare exception in the insect world. Out of around 200,000 known moth and butterfly species, just 0.1 per cent are carnivorous.

"Carnivory is exceptionally rare in caterpillars," Prof Adam Hart, an ecologist, conservation scientist and entomologist at the University of Gloucestershire, who wasn't involved in the study, told *BBC Science Focus*. "In fact, it's only known from a group of species in Hawaii."

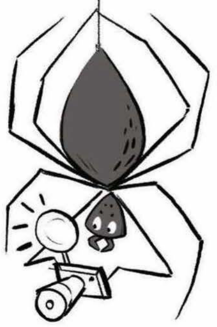
This new species survives by scavenging: it feeds on weak or dead insects that get caught in spider webs, chewing through the silk if necessary to reach its meal. As it drags its silk case (the outer layer that protects it before it turns into a moth) through the sticky threads, bits of exoskeleton and insect limbs accumulate.

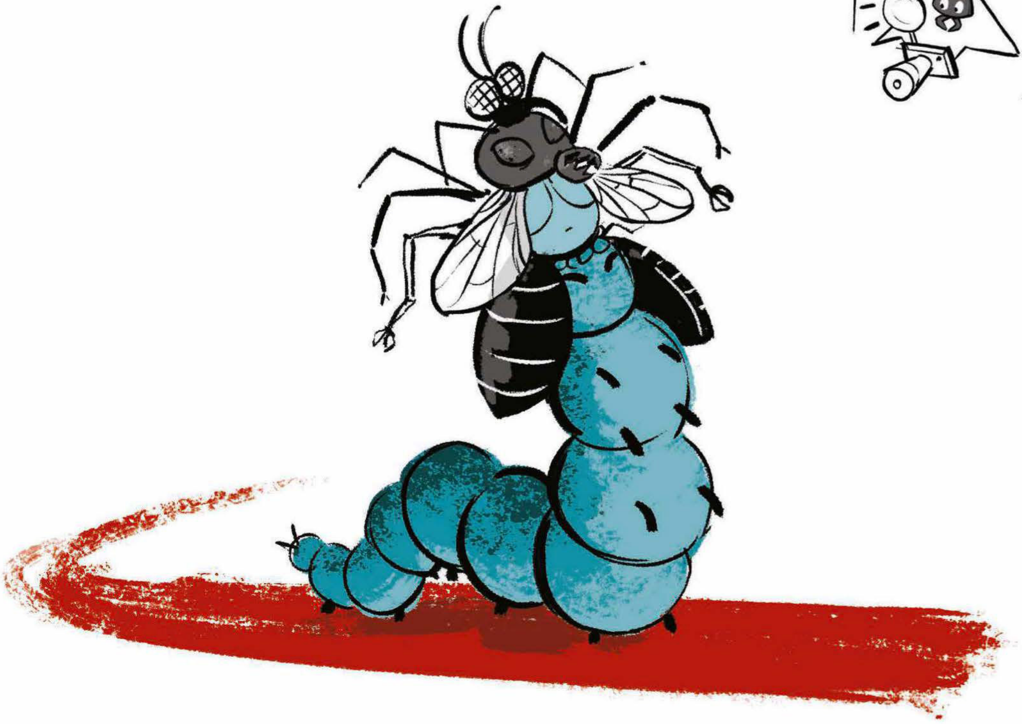
In total, the researchers identified body parts from more than six different insect species attached to these caterpillars. But this is no random collection – it's artfully curated. The caterpillar creates a gruesome but effective suit of armour from the corpses of its prey.

"The body parts are carefully measured for size before the caterpillar weaves them into its collection," wrote the authors of the study, published in *Science*. The caterpillar rotates parts for the best fit and chews oversized pieces down before stitching them in.

The researchers, from the University of Hawaii, raised the Bone Collector caterpillars in captivity and quickly noticed another unsettling behaviour: cannibalism. This explained why the caterpillar is only ever found living alone in the wild.

"This is certainly up there with the weirdest and most wonderful invertebrate I've heard of for some time," Hart said.





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adult allergy expert at King's College London, said that his team was "very pleased with the results."

"Constant fear of life-threatening reactions places a huge burden on people with a peanut allergy," he said. But this trial offers hope that adults with severe allergies could be desensitised.

All the participants were diagnosed with a severe peanut allergy at Guy's and St Thomas' NHS Foundation Trust. They started out by eating tiny amounts of peanut flour mixed with food under strict supervision. The first dose was 0.8mg – less than 0.3 per cent of a whole peanut.

Based on how well they were able to tolerate microscopic amounts, their doses were gradually increased every two weeks, always under supervision. When they were able to tolerate 50mg to 1g of peanut protein (the equivalent of two to four whole peanuts) they switched to real peanuts, peanut butter or peanut products.

Chris, 28, who took part in the study, said: "All of my life, I had associated the taste and smell of peanuts with fear and death." Now he eats four peanuts every day with breakfast to maintain his immunity.

PALAEONTOLOGY

The dinosaur graveyard that's rewriting prehistory

A fossil treasure trove in Alberta, Canada is changing how scientists understand the behaviour, biology and extinction of one of the Cretaceous period's strangest herbivores

When you think of dinosaur fossils, you probably picture parched deserts or badlands scorched by the Sun. But one of the world's richest dinosaur graveyards is buried in a less likely setting: a quiet patch of forest in northern Alberta, in Canada.

It's called the Pipestone Creek Bonebed and it's home to tens of thousands of bones – all from a single, bizarre-looking species of horned dinosaur called *Pachyrhinosaurus.*

The site, and the mystery of why so many of these animals died at once, is the focus of a new episode of *Walking With Dinosaurs* – the landmark BBC series returning to screens after more than two decades (see more on p26).

We spoke with Prof Emily Bamforth, a palaeontologist and curator at the Philip J Currie Dinosaur Museum in Alberta. Her research on *Pachyrhinosaurus* features heavily in the new series, using cutting-edge technology to find out what happened when an entire herd was wiped out.

THE DINOSAUR WITH A BOSS

Pachyrhinosaurus isn't a household name – yet. But it's one of the most distinctive members of the ceratopsian family, which includes the more familiar *Triceratops.* "They're a smaller, older cousin," Bamforth said. "But instead of having a horn on their nose, like *Triceratops*, they had this huge bony mass we call a 'boss'. They're the only horned dinosaur that has that."

So far, three species of *Pachyrhinosaurus* have been identified – all from northern latitudes, in places like Alaska and Canada.

These dinosaurs – which could grow to be over six metres (20ft) long and weigh more than two tonnes – migrated in enormous 'megaherds' numbering in the thousands.

Bamforth compares the trek to modern-day caribou migrations – the longest distance animal land migration on Earth – only on a far grander scale.

The fossil site they left behind is just as colossal.

"There are upwards of 10,000 individuals preserved here," Bamforth said. "It's one of the densest bone beds in North America – we're talking 100 to 300 bones per square metre (11 square feet), and the site stretches back into the hill for at least a square kilometre (0.4 square miles). It's a hugely dense bone bed that is very, *very* large – and that makes it tremendously significant."

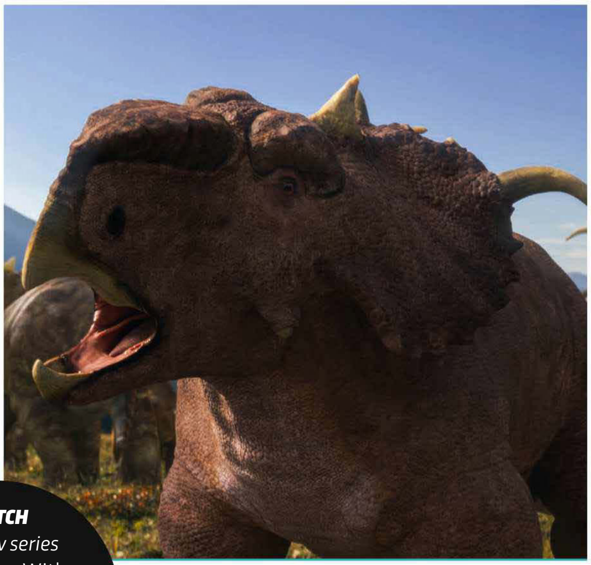
"The story of this particular herd of *Pachyrhinosaurus* is ultimately a tragic one"

A MYSTERY IN THE MUD

With such a high concentration of fossils, the question is: how did so many dinosaurs die in one place, at the same time?

"The story of this particular herd of *Pachyrhinosaurus* is ultimately a tragic one," Bamforth said. "We know they all died at once in some kind of catastrophic event, and we know that whatever killed them wiped out almost every member of the herd

WATCH
The new series of Walking With Dinosaurs *is now available in six episodes on BBC iPlayer*
iPLAYER



ABOVE LEFT Other fossils, including this leaf, were found and examined by Prof Emily Bamforth and palaeontology lab technician Jackson Sweder

ABOVE The Greek name *Pachyrhinosaurus* means "reptile with a thick nose"

indiscriminately – big, little, old and young." The mass die-off happened around 72 million years ago, well before the asteroid impact that famously wiped out the dinosaurs.

"We think it was a catastrophic flooding event," Bamforth said. "Possibly from monsoon rains in the nearby mountains, or even a hurricane-like storm washed inland. It would have been similar to flash flooding events that happen today, but on a more massive scale."

The result was a disaster for the dinosaurs – but ultimately ended up being a scientific windfall. The sudden burial preserved a remarkably intact snapshot of the herd, including individuals of all ages: a single moment in time captured in extraordinary detail.

It wasn't just palaeontologists who benefited from this disaster. "There's evidence that theropods like *Albertosaurus* and smaller raptor-like dinosaurs scavenged the carcasses after the flood," Bamforth added. "It would've been a smörgåsbord for them."

LESSONS FROM PIPESTONE CREEK BONEBED

Finding one dinosaur skeleton is rare. Finding thousands in a single layer? That's virtually unprecedented. And it's giving scientists the chance to ask questions that are usually impossible in dinosaur palaeontology.

"Usually, when we study dinosaurs, we find one or two – if we're lucky, maybe there's a dozen," Bamforth said. But, given the sheer volume of fossils that are all from a single herd, Pipestone Creek offers a rare window into what's known as intraspecific variation: the natural differences that occur between individuals of the same species.

Just as no two people look exactly alike, *Pachyrhinosaurus* are likely to have varied in size, ornamentation and behaviour. Bamforth and her team are especially interested in the frills that crown their skulls – structures that appear to differ subtly from one individual to the next.

"We're coming to understand that almost every *Pachyrhinosaurus* had a slightly different frill," she explained. "We think maybe that helped them recognise each other in the herd."

The bony bosses on their noses are also noticeably varied. What they were used for – whether for combat, attracting mates, recognising other individuals, or a mix of all three – is still under investigation.

A FIELD IN FAST FORWARD

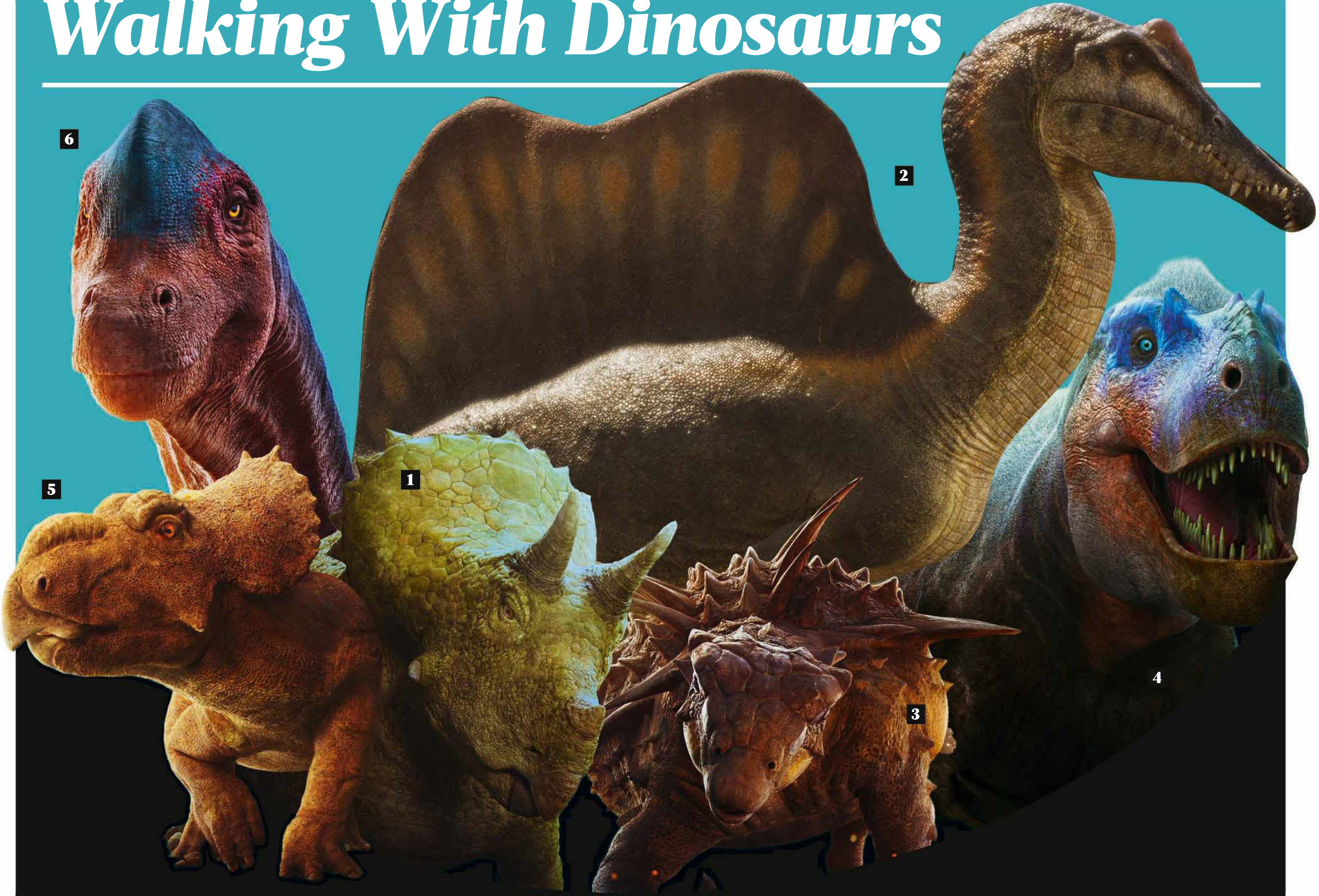
Since the original series of *Walking With Dinosaurs* aired in 1999, palaeontology has changed dramatically, with Pipestone Creek being just one of the many windows into prehistory.

"The focus used to be on just finding dinosaurs and describing them," Bamforth said. "Now there's more of an emphasis on understanding their relationship with the world they lived in."

That shift has been driven, in part, by public fascination. "Dinosaurs are more popular now than they've ever been, and because of that, the field of palaeontology is moving at a tremendous pace," Bamforth said.

If Pipestone Creek proves anything, it's that dinosaurs still have secrets to share – even after 72 million years.

The main characters of *Walking With Dinosaurs*



1. Triceratops
Weighing up to eight tonnes and stretching nearly 9m (30ft) long, *Triceratops* was the largest of the horned dinosaurs. With 1m (3ft)-long brow horns and a vast frill, it likely evolved alongside *T. rex* in an evolutionary arms race between prey and predator.

2. Spinosaurus
Larger than *T. rex*, *Spinosaurus* was a predator like no other and built for life in the water. With a 2m (6.6ft) sail on its back, a powerful paddle-like tail and webbed feet, it was perfectly adapted to swim and hunt in the rivers and swamps of ancient Morocco.

3. Gastonia
Gastonia is one of the spikiest dinosaurs ever discovered – an armoured member of the herbivorous ankylosaur family covered in defensive spikes. Unlike most of its kind, it was social: fossils of multiple juveniles found together suggest these youngsters found safety in numbers.

4. Albertosaurus
A smaller (but no less deadly) cousin of *T. rex*, *Albertosaurus* was built for speed. Capable of hitting speeds of over 48km/h (30mph), they were agile pack hunters. Fossils found in groups suggest they may have hunted cooperatively to take down larger prey.

5. Pachyrhinosaurus
A cousin of *Triceratops*, *Pachyrhinosaurus* lacked brow horns and instead had a thick bony boss on its nose, which was likely used in combat. Each one had a unique horn arrangement on its frill – like a fingerprint – which scientists believe helped them recognise each other within their vast herds.

6. Lusotitan
At 25m (82ft) long and over 40 tonnes, *Lusotitan* was a Jurassic giant that roamed ancient Portugal when Europe was just a patchwork of islands. A relative of *Brachiosaurus*, it had air sacs and hollow bones to support its size.

BBC STUDIOS/LOLA POST PRODUCTION X5

2000T

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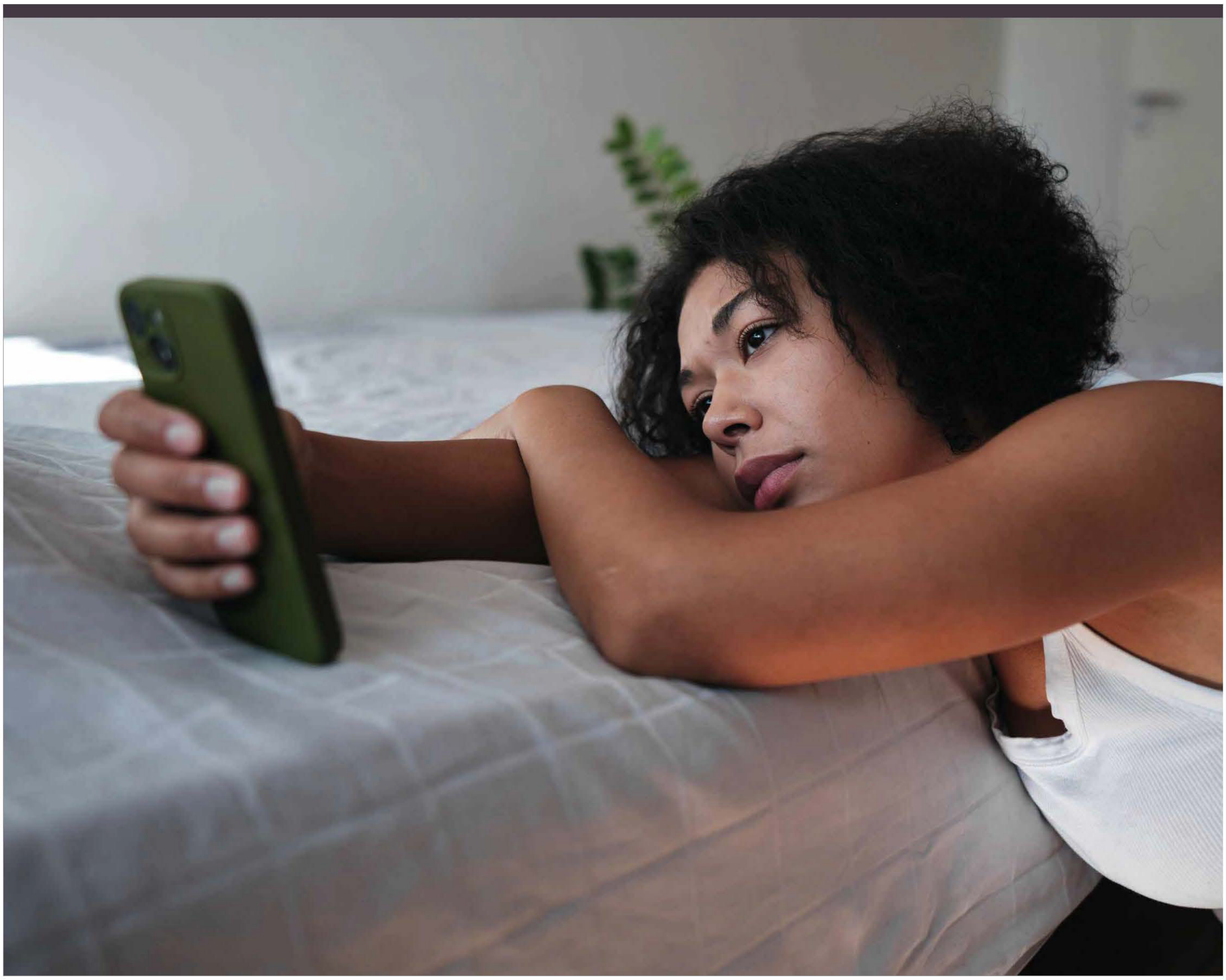
THE SCIENCE BEHIND THE HEADLINES



REVIEW

People are using AI chatbots as psychotherapists. We asked an actual therapist if that's a good idea

Artificial intelligence could make mental health care more accessible, but is it wise to trust your wellbeing to a chatbot?

BBC

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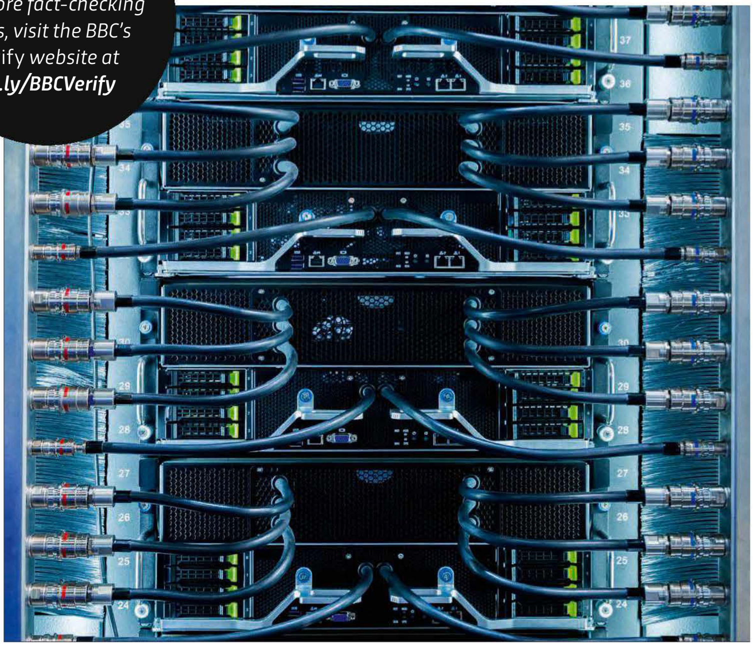


ABOVE The more sophisticated AI tech gets, the more uses it gets put to, but is providing mental health support an appropriate application?

LEFT An algorithm may be able to emulate empathy, but how effective is its advice for people seeking mental health support?

If you've spent even a brief amount of time interacting with an artificial intelligence (AI) chatbot, you'll likely appreciate the technology's potential for acting as a personal therapist. If I'm ever feeling down or worried, I turn to Claude, a model from Anthropic, the AI safety and research company. It's a great listener and isn't judgmental. What's more, at least on the surface, Claude's advice usually seems measured and draws on genuine psychological principles.

More people are turning to AI for this kind of relationship. Beyond the general-purpose AI models, such as ChatGPT and Grok, there's an increasing number of AI bots designed specifically for therapy, including Woebot (founded by psychologist Dr Alison Darcy) and Therabot (developed by researchers at Dartmouth University in the US).

None of them yet have any kind of official regulatory approval in the UK or US, but the demand is clearly there. It's telling that the most popular bot on Character.ai (a platform that allows users to create their own AI characters and share them with others) is one called 'Psychologist', created by a psychology student in New Zealand to provide mental health support. Psychologist has apparently attracted over 100 million interactions.

> **"A bot can only imitate some elements of compassion"**

ALWAYS THERE FOR YOU

The appeal of an AI-therapist is obvious: they're in your pocket any time you need them, they're far cheaper than a human therapist and you can tell them stuff without worrying about potentially embarrassing yourself. The creators of the burgeoning range of AI therapists argue that they're just what we need when conventional mental health services are struggling to cope with demand. Meta's CEO Mark Zuckerberg even joined the chorus in April this year, telling listeners of the 'Stratechery' podcast that he thinks everyone could benefit from having a therapist and that AI can fulfil that role.

Is Zuckerberg right? He certainly glossed over some extremely worrying developments. For instance, in 2024, a 14-year-old boy tragically died by suicide and his parents blamed his relationship with a bot he used on Character.ai. When the boy shared his suicidal thoughts, the bot appeared to encourage him rather than recognising the crisis.

Prior to that, Woebot and another chatbot called Wysa made headlines for failing to respond appropriately when testers posing as children described obvious instances of being abused.

As serious and tragic as these examples are, they're the sort of problems that can arguably be addressed through better programming and safety protocols. But even if that's the case, psychologists and medical ethicists warn that AI bots can't ever truly replace a human therapist. In a statement released in May this year, the British Psychological Society said: "AI cannot replicate genuine human empathy and there's a risk it creates an illusion of connection rather than meaningful interaction."

Research has uncovered some of the key successful ingredients of therapy and one of them is called the 'therapeutic alliance' – it's essentially a form of trust and shared understanding that develops between a therapist and client over time. This is where many experts believe AI bots will always fall short.

Zoha Khawaja is an AI ethics researcher at Simon Fraser University in Canada. In 2023, she co-authored a paper titled "Your robot therapist is not your therapist: Understanding the role of AI-powered mental health chatbots." Speaking about her paper, Khawaja said that an AI bot can never achieve a true therapeutic alliance with you – even if it appears to show empathy and understanding. "A therapist must go beyond understanding their patient's needs and be motivated to alleviate their suffering to help them gain back their autonomy and achieve their goals, something that an AI chatbot can't do," she said. "[A bot] can only imitate some elements of compassion, such as empathy."

Khawaja adds that one of the main risks of using AI therapists is becoming overly dependent on them and having an exaggerated sense of their capabilities, potentially leading to their misuse. She gives the example of Tessa – an eating disorder (ED) trained

GETTY IMAGES, ALAMY

“Meaningful mental health support can occur without direct human interaction that’s characteristic of conventional therapy”

therapy chatbot that was designed and clinically tested by experts and funded by the National Eating Disorders Association (NEDA) in the US.

“Tessa’s purpose was to be used as an additional preventative tool to help ED patients access resources for ED treatment. It was never designed to replace human roles” Khawaja says. “NEDA, however, used this chatbot to fully automate its help hotline, replacing its human volunteers and staff. Because this chatbot wasn’t monitored, within a month, it began providing inappropriate and noxious dieting advice to ED patients who already suffer from hyper-fixation on their body."

TESTING AND TRAINING

These important concerns aside, the latest research on AI therapists is encouraging. Earlier this year, researchers at Dartmouth University published the results of a trial comparing the outcomes for over 100 patients with depression, anxiety or eating disorders who used Therabot for four weeks against the outcomes for a similarly sized control group who were on an eight-week waiting list to use the AI therapist.

After four and eight weeks, the AI therapy group showed significant improvements in their symptoms compared with the control group. The AI even achieved the same level typically seen in outpatient therapy with a human clinician (about a 50-per-cent reduction for depression, 30-per-cent for anxiety and 19-per-cent for eating disorders).

Perhaps most impressive, given the concerns raised by some psychologists, the participants using Therabot gave it similarly high scores for therapeutic alliance as are often seen for human therapists.

Dr Michael Heinz, the trial’s lead author, acknowledged that, “For some people facing some types of challenges, the understanding that their therapist is another human being – someone who has personally experienced happiness, suffering and everything in between – can be a very important part of therapy.” But added that the new trial provides “compelling evidence that meaningful mental health support can occur without direct human interaction that’s characteristic of conventional therapy.”

Heinz explains that the question of risks and benefits comes down to how models are trained and safety tested. “Our study demonstrated that… expert fine-tuning and rigorous clinical safety and efficacy testing [can] ensure that the model adheres to best practices in mental health care, providing intervention that aligns with therapy best practices and evidence-based recommendations.”

He cautioned that a ‘general foundation model’ (one that hasn’t been specifically trained to act as a therapist) can give well-meaning, but potentially harmful, advice. For instance, a chatbot could encourage you to avoid situations that trigger your anxiety, when evidence suggests that this kind of avoidance can perpetuate mental health difficulties.

This chimes with the experiences of clinical psychologist Dr Nick Wignall, author of the popular digital newsletter *The Friendly Mind*. He’s found that even the most advanced models tend to be overly supportive and sympathetic. Yet, as he explains, “One of the main functions of a good therapist is that, in addition to being supportive and empathetic, they’re also highly skilled at challenging you at the right time, in the right way and about the right things.” Wignall doesn’t think AI therapists are necessarily incapable of doing this, but it might often come down to the way that you interact with them.

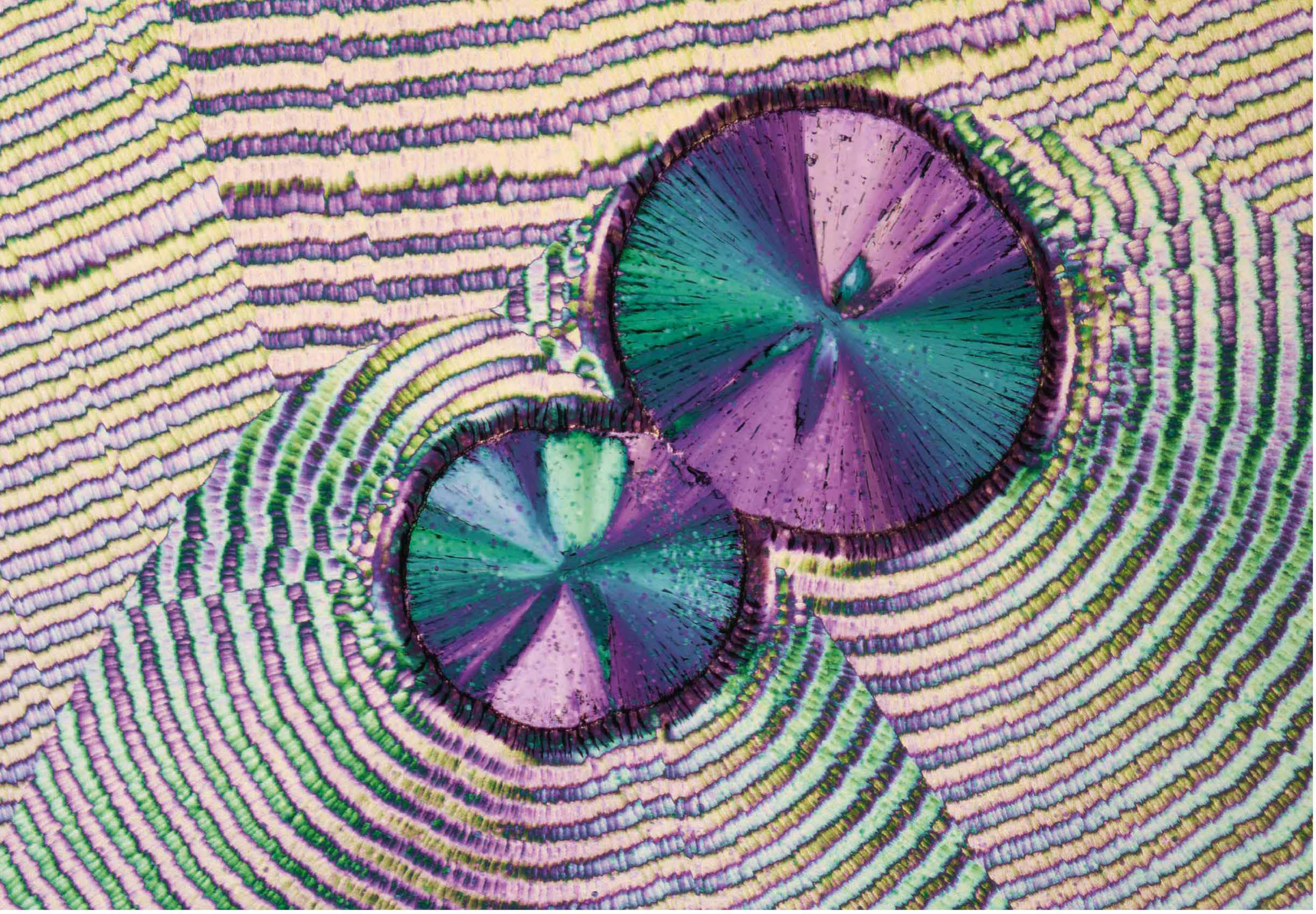
If you’re using AI as a form of therapeutic support, Wignall’s advice is to think carefully about the prompts you use. “While everyone will likely need to experiment on their own to find the right balance,” he says, “a good prompt I tend to use whenever I ask AI anything about myself is for personal growth is: You are a skilled listener, highly empathetic and sensitive, but I’m more concerned with growth than support right now. I want to be challenged, pushed to consider alternative viewpoints and made aware of potential blind spots or weaknesses I may have. Given that, here are my questions…”

by **DR CHRISTIAN JARRETT**

Christian is a cognitive neuroscientist, and author of Be Who You Want: Unlocking the Science of Personality Change.

BELOW Human interaction is an important part of conventional therapy, but research suggests it may not always be necessary

ALAMY, SCIENCE PHOTO LIBRARY



ABOVE Ferrous sulfate (seen here under a microscope) is a type of iron used to treat iron-deficiency anaemia

ANALYSIS

You're probably not getting enough iron. Here's what it could be doing to your body

Iron can be easily found in a multitude of food sources to suit all diets. So why are so many of us deficient in the micronutrient?

A recent review published in *The Lancet Haematology*, led by Dr Ashley Benson and Dr Jamie Lo from Oregon Health and Science University has reported that iron deficiency affects up to one in three women, making it the most common nutrient deficiency in the world.

Iron plays a vital role in the body. It's essential for making haemoglobin (the protein in red blood cells that carries oxygen from the lungs to the rest of the body). It also supports energy production, brain development and a healthy immune system. Without enough of it, the body struggles to function at its best and in children, iron deficiency can hinder growth and cognitive development.

The average adult human body contains just 3–4g (about 0.1oz) of it – a tiny amount that classifies it as a micronutrient. So why is it so difficult for our bodies to maintain healthy iron levels?

There are two main reasons. The first is that many people simply don't eat enough iron-rich foods, such as meat, pulses and legumes, green leafy vegetables, dried fruits, nuts and seeds, and whole grains. The second reason is that even when iron is present in the diet, the body doesn't always absorb it efficiently.

ABSORBING IRON

How efficiently the body absorbs iron depends on both dietary and individual factors.

In food, iron exists in two chemical forms: haem and non-haem iron. Haem iron is found in the blood and muscle tissue of animals, and so is present in meat and fish (the redder the meat, the more haem iron it contains). Non-haem iron, on the other hand, is found in plant-based foods and iron-fortified products.

Compared to haem iron, which is absorbed at a rate of around 14–40 per cent, non-haem iron is absorbed far

less efficiently, typically between 2–20 per cent. Its absorption can be reduced by certain substances found in food that bind to iron and make it harder for the body to absorb.

These include calcium, as well as naturally occurring compounds in plant-based foods such as polyphenols (found in tea and coffee), phytates (in whole grains and legumes) and oxalates (in spinach and some leafy greens). This is why vegetarians and vegans may find it more challenging to consume adequate amounts of absorbable iron.

Beyond diet, inflammation – whether from acute illness or chronic conditions, such as obesity – can also reduce iron absorption. With global rates of obesity and chronic disease on the rise, this presents a further challenge in reducing the global burden of iron deficiency.

IRON DEFICIENCY

Since iron is essential for the production of red blood cells, deficiency can lead to anaemia – a condition characterised by low levels of haemoglobin, the protein that gives blood its red colour and carries oxygen.

According to the World Health Organization, anaemia affects 31 per cent of adult women of reproductive age, 36 per cent of pregnant women and 40 per cent of children under five. It's estimated that about half of all anaemia cases worldwide are caused by iron deficiency. Common signs and symptoms include pale skin and gums, tiredness, shortness of breath and a racing or irregular heartbeat (known as heart palpitations).

Iron deficiency – especially when it leads to anaemia – can have serious health consequences. It has been linked to a weakened immune system, complications during pregnancy and childbirth, higher risks of death for both mothers and babies, and delays in children's growth and brain development.

Not only are the consequences of iron deficiency particularly severe in women and children, but they are also at greatest risk of developing it. Menstruating women have high iron needs due to monthly blood loss. Pregnant women require additional iron for the development of the placenta, the foetus and increased blood volume. Children need iron for rapid growth and brain development. Adolescent girls, who are both growing and menstruating, are at especially high risk.

In their paper, Benson and Lo brought together a panel of 26 experts and four patient representatives. Their collective recommendations call for a more proactive and inclusive approach to managing iron deficiency, with a particular focus on those most at risk.

The panel emphasised the need for routine screening during pregnancy and early childhood – times when the body's demand for iron is especially high. They also highlighted the importance of using ferritin, a

> "Iron deficiency – especially when it leads to anaemia – can have serious health consequences"

ABOVE Dietary iron can be found in a diverse range of foods

RIGHT Iron supplements are the first option for dealing with any deficiencies. But beware: consuming iron in excess can be harmful, so the NHS recommends limiting daily iron supplementation to 17mg, unless otherwise advised by a qualified doctor

ALAMY X2

blood protein that reflects liver iron stores, as a reliable marker for diagnosing iron deficiency and deciding when to intervene.

When treatment is needed, oral iron supplements are the first choice – they're effective, widely available and affordable. For people who experience side effects like nausea or constipation, the panel suggested taking supplements every other day to improve tolerability. In more severe cases, or when oral iron isn't effective or well-tolerated, intravenous iron (given through a drip directly into a vein) may be necessary.

Finally, the panel emphasised that iron deficiency shouldn't be treated as a separate issue. Instead, it should be part of routine care in services that support mothers and children – like pregnancy check-ups, child health visits and nutrition programmes – to make sure iron levels are monitored and managed alongside other important aspects of health.

IRON ADVICE

While some people may need medical treatment for iron deficiency, many cases can be prevented through everyday choices, especially when it comes to diet.

Start by including more iron-rich foods in your meals, such as pulses and legumes, green leafy vegetables, seeds and nuts and iron-fortified breakfast cereals (look for low-sugar options for children and adolescents).

If you eat animal products, moderate amounts of red meat – limited to 70g (2.5oz) per day on average, as recommended by the UK Eatwell Guide – can provide a well-absorbed source of iron.

If you follow a mostly plant-based diet, try pairing iron-rich foods with sources of vitamin C – such as lemon juice, tomatoes or strawberries – to help your body absorb the iron more effectively.

Be mindful of when you drink tea or coffee, as they contain polyphenols that can inhibit iron absorption if consumed with iron-rich foods. The same goes for taking iron supplements – timing matters. Taking them with a source of vitamin C (a glass of orange juice, for example) can significantly boost absorption.

If you're in a higher-risk group – such as if you're pregnant, menstruating or caring for young children – or if you're feeling unusually tired, it's worth speaking to your doctor. A simple blood test can check whether your iron levels are where they should be. In children, iron deficiency may also show up as a poor appetite or unusual cravings for non-food items, like chewing ice.

Iron deficiency is common, but it's also manageable and often preventable. With awareness and smart choices, keeping your iron levels healthy can be as simple as choosing what's on your plate. **SF**

by **DR JEANNINE BAUMGARTNER**
Jeannine is a lecturer in the Department of Nutritional Sciences at King's College London and an extraordinary associate professor in the Centre of Excellence for Nutrition at North-West University in South Africa.

INNOVATIONS

PREPARE YOURSELF FOR TOMORROW

TRIED AND TASTED

The 0% drink that still gets you tipsy

We swapped alcohol for Sentia for a week to see if we could be tempted to swap for good

SENTIA SPIRITS
GABA BLACK
SENTIA SPIRITS
GABA GOLD
SENTIA SPIRITS
GABA RED
50cl

To borrow a line from Elton John, it's a little bit funny, this feeling inside. As I write the article you're reading, I'm sipping on a potent brew, mixed with ice and tonic water, and I think it's beginning to hit. I don't feel tipsy, exactly, but I feel something. A light buzz. A twinkle in the synapses.

I'm hardly the first journalist to be drinking on the job, but in my defence, the stuff in the glass beside me isn't alcohol. It's Sentia, a concoction created by pharmacologist and addiction researcher Prof David Nutt. Billed as the future of drinking, Sentia is designed to have a neuroactive effect on the person drinking it.

You're supposed to feel the way you do after one or two alcoholic drinks. Relaxed, sociable, less inhibited, weirdly good at pool. Effects last 30–40 minutes and all with no hangover, no addictive qualities and barely any calories. Make mine a double, barkeep.

But with no alcohol and no caffeine, how does Sentia work? The idea is that it boosts the activity of a neurotransmitter in the brain called GABA (gamma-aminobutyric acid, but try saying that after a few drinks). It's sometimes described as an off-switch, something that slows down nerve impulses in our overexcited grey matter. The upshots include lower anxiety, changes in mood and improved sleep.

STRESS BUSTING

GABA occurs naturally in our bodies and we can also get it through our diets. But there's debate about whether ingested GABA is bioactive – some researchers doubt that it crosses the blood-brain barrier – so Sentia doesn't claim to simply increase the amount of GABA swilling around your head.

Instead, the blend of herbs and botanicals in the drink are supposed to increase the effectiveness of the brain's natural GABA and help absorption of GABA enhancers in the gut.

Right now, there's not much peer-reviewed evidence to back this up. Researchers at the University of Exeter have taken brain scans of people drinking Sentia and their electroencephalograms were consistent with relaxation and sociability. Nutt is also conducting his own research and GABALabs – the company that makes Sentia – is funding other work.

It's uncontroversial, however, to say that GABA has an effect on mood and behaviour, says Andrew Scholey, professor of human psychopharmacology at Northumbria. Scholey isn't involved with Sentia, but has authored papers on GABA. One, from 2023, looked at the brains of people with generalised anxiety disorder (GAD).

"What that found was, in this population of people with clinical GAD, GABA was lower in the individuals with higher anxiety," Scholey says. "So, there was a significant correlation."

Taste test

Chandra Sarkar, doctor
Tasted: Sentia Red

"It smells like a Christmas candle, but I'm not too keen on the smoothie texture of it. I didn't like it mixed with tonic, but over ice, it was quite enjoyable and after two servings, I definitely felt relaxed and a bit lightheaded. The effects weren't long-lasting, but if I was drinking it for the evening, I would have to pace myself. As a doctor, I'd also recommend that people check that the herbal ingredients don't interact with their medication."

Gentian Dema
legal executive
Tasted: Sentia Black

"I haven't had anything alcoholic for over two years, but I still look for refreshment, relaxation and stress relief when I drink something. But this wasn't to my taste at all. I found it lacking any sweetness or fruitiness. Drinking it was astringent, leaving my mouth feeling dry. I had to eat some grapes to remove the flavour. And unfortunately, I didn't get any buzz at all."

In another paper, this one from 2020, Scholey reviewed existing evidence on orally ingested GABA and whether it has an effect on stress or sleep quality. Despite mixed results, "there was a general pattern that GABA improved sleep quality and there was a hint that it was having an effect on reducing stress as well," he says.

BOTTOMS UP

I've been drinking Sentia for a week. During that time, I've monitored my sleep with an Apple Watch. It showed – perhaps unsurprisingly – that I get more sleep and better quality sleep on Sentia compared with alcoholic drinks.

What can't be captured with a wearable device is how you feel when you're drinking Sentia. For me, at least, the effect is subtle. Almost so subtle that I wonder if it's a placebo and I'm just imagining it. But there is *something*. I feel relaxed and content in a way that I don't after drinking water or soft drinks.

Scholey says that measuring the felt effects of psychoactive substances can be difficult. "With many recreational drugs, there's a very clear felt effect," he says. "With something like alcohol, it's quite hard to separate the actual psychopharmacological effects from things like expectancy."

Anecdotally, Scholey knows people in the psychopharmacology community who have tried Sentia. Results are mixed, he says. Some feel a potent effect, some none at all.

My gut says I'm somewhere in the middle. And whatever the efficacy, drinking Sentia is a pleasant experience. There are three flavours, of which I've tried two. Both have complex botanical notes – they're more like cocktails than soft drinks.

It's not hard to understand the appeal as people continue to question their relationship with alcohol. In the UK, the no-and-low alcohol category more than doubled its sales year-on-year in 2024. Sentia isn't the only brand that promises a psychoactive effect. Impossibrew, another British brand offering zero-per-cent products, claims its drinks help people relax by affecting their brain waves. Scholey also works with Arepa, a brand in New Zealand that produces 'functional' drinks that assist cognitive function.

For Nutt, who knows better than most the long-term and population-wide damage that alcohol can cause, Sentia gives drinkers a healthy option at the bar. As for me, I may be 50-50 on whether it worked, but listen, I'll have one if you're having one.

by **IAN TAYLOR**
Ian is a freelance science writer and the former deputy editor of BBC Science Focus.

Buying a used electric vehicle is less risky than you think

With secondhand EV prices starting to fall, here's what you need to know about their batteries if you're considering buying one

Ask most people if they'd buy a secondhand electric car and they'll walk the other way. Others will roll their eyes and say they wouldn't want to take the risk. But a few will say they already have... and it's the best thing they've ever done. I'm one of them.

15 years of daily electric vehicle (EV) driving, owning seven different electric models and covering 170,000 battery-only miles gives me a clear perspective. And in all that time and all those miles, nothing has gone wrong.

I got my first and, so far, only EV repair bill the other day. It was for £375 for front control arm bushes on the Tesla Model 3 that I've owned for five years and have driven for 50,000 miles.

MOTORING MADE SIMPLE

Buying a used EV is less risky than buying a used combustion-engine car because there's much less to go wrong. There are around 20 moving parts in an EV drivetrain, compared to over 200 in a petrol- or diesel-powered vehicle. Clutches, gearbox control units, fuel pumps, exhaust gas recirculation valves… the list of stuff that can, and does, go wrong in combustion-engine vehicles seems endless. Meanwhile, multiple studies show that EVs break down less than combustion cars.

Servicing an EV involves replacing the cabin filter, changing brake fluid every three years and rotating tyres to even out wear. That's it, because there are so few friction-based parts.

Once you understand how mechanically simple an EV is, you begin to know what you need to look out for. And the main thing is the battery. This is the greatest concern for used-EV buyers. But we now have billions of miles of EV data to show that the failure rate of their lithium-ion batteries is actually tiny.

Most EVs come with an eight-year, 100,000-mile battery warranty, so if the capacity drops below 70 per cent, the battery will be replaced free of charge. I've driven EVs out of warranty with 250,000 miles on their original battery packs that still hold good charge and range. We're even seeing ex-taxi EVs – sometimes with as many as 300,000 miles – still running and charging well.

Most experts now agree that an EV's battery will outlast the car's chassis. Consumer Reports estimate that the average battery pack has a life expectancy of 200,000 miles, while a Geotab study of 6,000 EVs showed a loss of battery capacity of 10 per cent over 10 years. But after a decade of use, a combustion engine will also lose efficiency through mechanical wear.

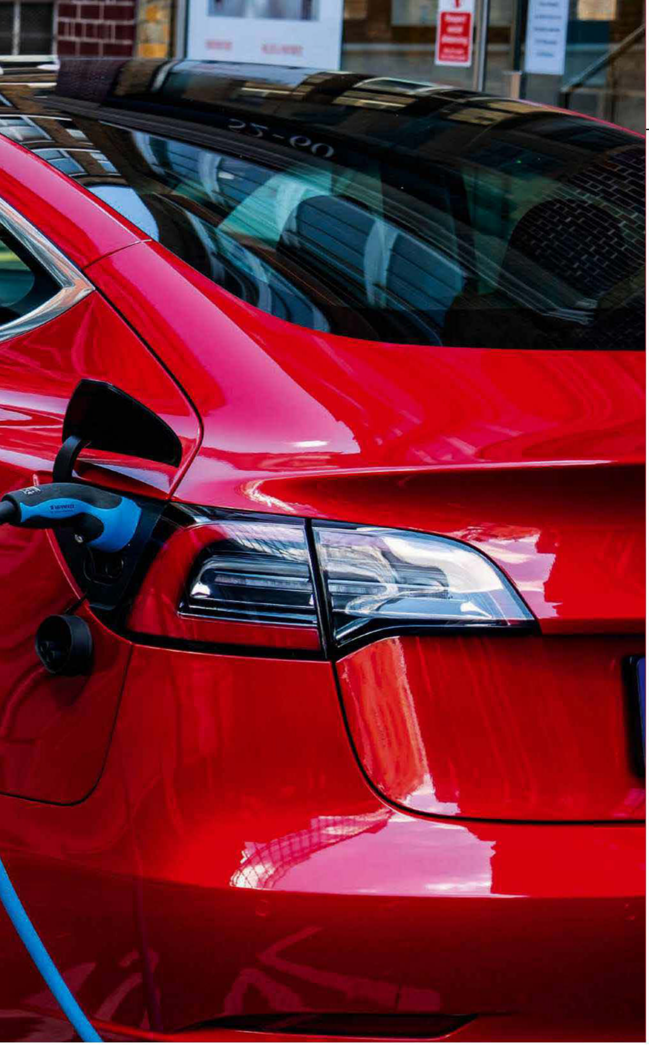
WHAT TO LOOK OUT FOR

Dealers now offer State of Health (SOH) certificates for batteries and many EVs have software that the owner can use to check the SOH themselves. I did it on my Tesla at 50,000 miles and found I have 93-per-cent capacity left. If you buy from a dealer, make sure you get a SOH certificate or, if it's a private sale, get the battery capacity checked. Anything around 90 per cent means there's plenty of life left, as on many models we're seeing cell degradation levelling off after this point.

There are some exceptions, though: the early Nissan Leaf had battery cooling issues and loses range and capacity faster than other EVs. Early Renault Zoes have battery management problems and the oldest electric Smart EVs can be difficult to repair. The oldest BMW i3s have reliability glitches, and according to *WhatCar* so does the MG4 and Vauxhall Corsa E.

ABOVE Since April 2024, the UK public network of EV charging points has grown by 30 per cent, with an estimated 73,000 stations

ABOVE RIGHT There's no official record of how many private charging points there are in the UK, but charge point mapping app Zapmap estimates over a million homes have one



ALAMY X2

As a general rule, avoid the earliest EVs, which may look alluringly cheap (some as low as £3,000). Battery tech has now improved, bringing with it longer ranges, faster charging times and better software. Some may also have CHAdeMO plugs that are being phased out in many countries, although you can buy adaptors to convert to the Combined Charging System (CCS), now used on all chargers. Go for EVs from 2017 onwards and you'll be buying more modern technology.

We're seeing premature failures in hybrid batteries because of their greater charging cycles that degrade the pack quicker. Hybrids are proving less reliable than battery-only EVs because they have two power trains – a petrol engine and a battery – so twice as much to go wrong. They also cost more to maintain and their range on electricity alone is much less than an EV – typically 20–40 miles from a plug-in hybrid. Mild hybrids and full hybrids run mainly on a petrol engine and aren't proper EVs.

On some EVs, there have been problems with charging port flaps, charging ports and cables, but these are relatively rare. Before you buy, make sure you check the functionality of the port and flap by charging for a while and watch the central screen for any charging warnings or a failure to connect. Ask the seller to charge the battery to 100 per cent before you arrive and check what the indicated range is. If it's significantly lower than the manufacturer's quoted range, walk away.

Most EVs will lose range in colder weather, but if the ambient temperature is warm, the range should be close to the official figure. EVs fitted with heat pumps give improved range in lower temperatures.

The 12-volt battery in some EVs – like in combustion cars – can lose charge over time, but this can affect the charging of the main battery and spook some of the software, so it's wise to change the auxiliary battery every three years.

Apart from electrical glitches, look for suspension wear on front control arms and bushes, and if there are any rattles or squeaks, ask why. EVs should be silent and silky smooth. There's now a large global data set on EV reliability and they're proving more reliable than petrol or diesel cars.

One very important thing to do before you buy, is to get a home charge box fitted (if you have space) so you can charge your EV outside your house, as you'll be able to access a low night-time tariff of 7.5p per kWh. That means the average cost of a full charge will be less than £15, or around 3p per mile. But, however you charge your secondhand EV, it'll be much cheaper than the eye-watering forecourt fill-ups you're used to with petrol or diesel vehicles.

by **QUENTIN WILLSON**

Quentin is an award-winning motoring journalist and transport campaigner. He presented BBC Two's Top Gear *for a decade, along with many other motoring and consumer shows.*

EDITOR'S PICKS...

This month's smartest tech

OUT OF CONTROL

Why haven't you gotten a controller for your smartphone yet? Not only is there a growing catalogue of premium games available in app form – from *Fortnite* to *Apex Legends* to *Resident Evil* – but also both Xbox and PlayStation now allow for Remote Play, which means you can get your console games onto your smartphone screen while your other half hogs the TV. There's a ton of options out there, but arguably the controller that sets the standard is now the Backbone Pro, which has added Bluetooth to play nice with pretty much any device you can find in your house.

Backbone Pro
£169.99, backbone.com

FORTNITE
Fortnite
ROBLOX

↑...GRILL OF MY DREAMS

This isn't new, but I've been thinking about buying one all year, so it's worthy of the June edit. Weber's Go Anywhere strikes a perfect balance between portability and utility that few products manage. It's smaller than a shoebox, yet there's enough cooking space to sizzle six burgers at once. There's also a new gas-powered version that's even more convenient…

Weber Go Anywhere
From £112, weber.com

→...BACK TO THE FUTURE

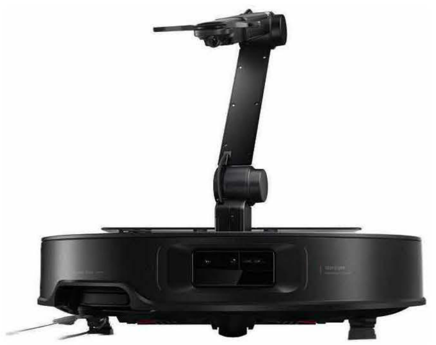
These might look like the first pair of headphones you ever plugged into your Walkman, but that's where the similarities end. Behind the retro-futuristic stylings, the Lightwear headphones offer wireless Bluetooth 5.4 connectivity (which is great for lossless audio), noise-cancelling tech with a transparency mode to hear the world around you and music controls on the ear cups. They run for 24 hours between charges and you can magnetically snap the ear covers on and off if you need to replace them. And, if you're really feeling nostalgic, you can pair them with KM5's wireless, portable CD player.

Lightwear Headphones Hp1
£159, km5.co.jp

↓...HIGHER-FI

B&W sets the bar when it comes to big, expensive, over-ear, wireless headphones. The finish and choice of materials made the Px7 S3's predecessor, the Px7 S2e, one of the most comfortable headsets to wear for long periods. For this update, B&W has improved the sound quality with biocellulose audio drivers and a dedicated built-in amplifier. We've yet to try them out, but B&W says this adds "more scale and energy to the sound".

Bowers & Wilkins Px7 S3
£399, bowerswilkins.com



↑ ...ARMED AND DANGEROUS

Unveiled at January's CES and now available for purchase, this robot vacuum cleaner (and mop) has an arm up on its competitors. No, it literally does: this is the first vac we've ever seen packing a robotic arm. Its creator, Roborock, says the Saros Z70 can move objects out of its way – think slippers, small bits of rubbish, toys and so on. Better still, if you've got a pet at home, you can effectively video call the robot to look through its cameras and chase your cat or dog around the house. I'm sure they'll love that.

Saros Z70
£1,699, Roborock.com

↓...OHM MY!

The Matador Travel Adaptor is ready to power your gadgets anywhere. It has five USB ports (two of them USB-C and one a fast-charging port) and a multi-country AC plug socket. As well as the discreet black version (below) it also comes in a high-vis, 'you'll never leave me in a hotel socket by mistake' orange, too.

Matador Global Travel Adaptor
$36 (£26)
matadorequipment.com

SFP420

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NEW *LEASH* OF *LIFE*

Cutting-edge anti-ageing advances could extend your dog's lifespan and help sniff out the secrets to human longevity too

by **DR ANDREW STEELE**

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ENVATO ELEMENTS, GETTY IMAGES

What a time to be a dog. Right now, it's estimated that owners spend around £2,000 (about $2,600) a year to take care of our favourite four-legged friends (sorry, cats), with that figure including up to £600 (almost $800) on grooming and £300 (nearly $400) on treats. But modern pooches aren't only pampered – they're enjoying longer, healthier lives than ever. One study of dogs in Japan found that their lifespans have increased by over 50 per cent since the 1980s.

That figure could rise further. A wave of cutting-edge canine science is sweeping the globe, with everything from the Dog Aging Project's 50,000-pet study, to biotech firms racing to develop anti-ageing drugs for dogs. It all means we could be less than a decade away from cracking the code of animal longevity.

And the best bit? These breakthroughs could unlock new ways for humans to live longer, healthier lives, too.

BREEDS APART

A lot of us think of the ageing process as an inevitable side-effect of being alive. As we get older, both people and pooches go grey, get slower and eventually succumb to a very similar collection of diseases, from arthritis to cancer.

But we now know that many of the diseases that come with growing older are caused by common biological processes. And some scientists believe a single pill could be developed that targets the underlying biology of ageing, which could keep many (or all) of these diseases at bay.

This is where dogs come in. Thanks to the enormous diversity between breeds, studying differences between them could help reveal a lot about the ageing process.

Think about it. Whether it's an Afghan hound or a yorkshire terrier, all domestic dogs belong to the same species – *Canis familiaris*. This means they all share the vast majority of their genes. Their DNA is similar enough that dogs from different breeds can mate and give birth to puppies, from the labradoodle (labrador and poodle) to the puggle (pug plus beagle).

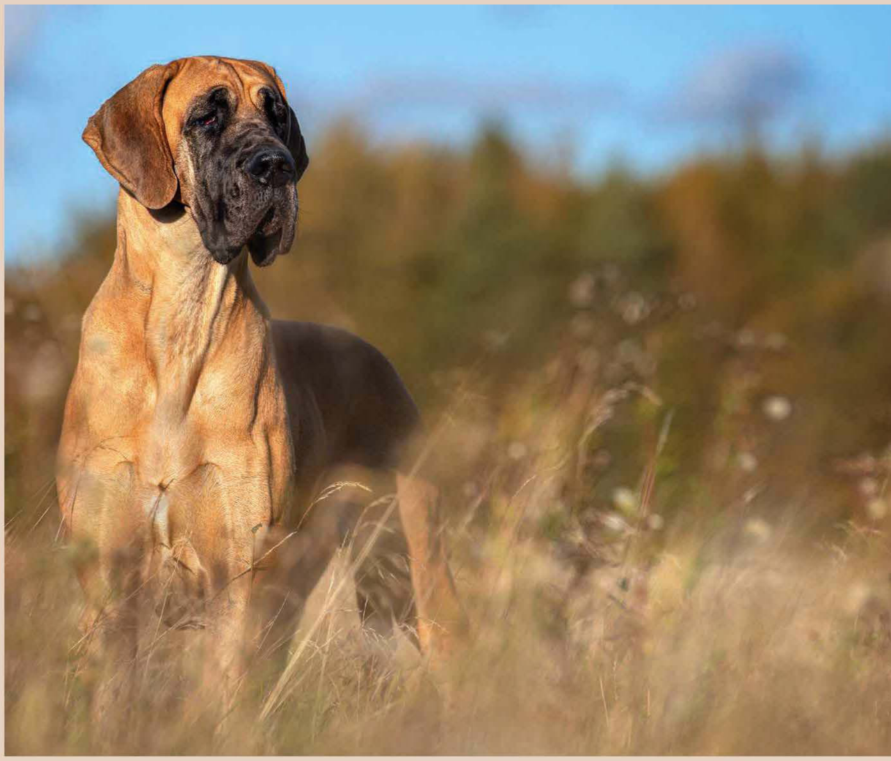
Yet although the genetic differences are few, the variety among dogs is huge – in how they look, how they act and how long they live. Some breeds, like the presa canario (a type of Spanish mastiff), live on average just 7.7 years. Others, like the miniature dachshund, can live nearly twice as long.

But surely, as you might be thinking, aren't the differences in lifespan all down to a breed's size? Well, yes, it's certainly a factor – as dog lovers are sadly aware, bigger dogs tend to live shorter lives. A US study of almost 10 million dogs found that 'giant' breeds lived an average of 9.5 years, while 'small' breeds lived 13.5 years. That's over 40-per-cent more time chasing sticks and barking at postal workers than the biggest dogs.

One reason for this could be risk of cancer – the more cells you have, the more chances you have for one of them to accrue the wrong combination of genetic mutations and turn into a tumour. (Tall humans reading: don't worry. While being taller is linked to a slightly increased risk of cancer, it's also associated with a lower risk of heart disease. When it comes to overall lifespan, these effects likely balance each other out.)

But here's the thing: size doesn't determine a dog's lifespan completely. For instance, among giant breeds, a great pyrenees (a very large mountain dog) lives about 11.5 years on average, while a similarly giant caucasian shepherd dog lives only around 5.4 years. This means that other genetic factors are at play.

That's because ageing is incredibly complicated. But ultimately, dogs show us how small genetic differences between breeds can drive big differences in longevity. And this suggests that it might be easier than we think to have an influence on ageing.



ABOVE Studies have shown that larger dog breeds don't tend to live as long as smaller dog breeds

LEFT Dog owners already spend thousands caring for their pets and keeping them healthy. Hence, the market for drugs or treatments that could extend the animals' lives is projected to be huge

DON'T STOP RETRIEVIN'

If just a few genes can shape how long an animal lives, could something as simple as a pill help do the same?

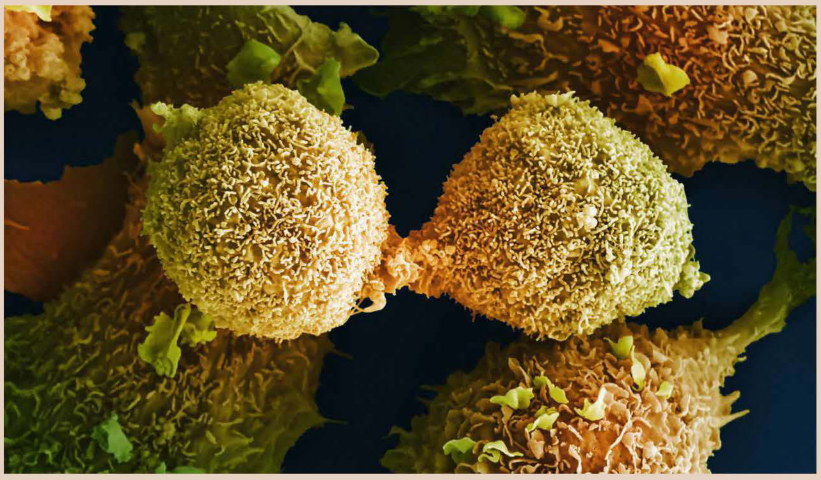
Dogs are a fantastic place to test this theory. Firstly, as previously mentioned, they get similar diseases to humans as they age.

Secondly, dogs are almost unique in how closely they share our environment. Unlike lab mice, who live in sterile, climate-controlled cages, our pets breathe the same air we do, drink the same water and often share our daily routines – not to mention our snacks and, if they're lucky, our beds. Thanks to thousands of years of domestication, dogs have gut bacteria (microbiomes) far more similar to ours than those of mice or pigs.

Also, while sad for their owners, dogs' shorter lifespans are an advantage for longevity experiments. The longer an animal lives, the longer you have to wait to find out if your longevity treatment worked. This makes medium-to-large dogs, with their ten-year lifespans, a more practical starting point than humans.

Combined, all of this convinced longevity scientists Professors Daniel Promislow and Matt Kaeberlein to launch the Dog Aging Project in 2014.

"I think what really got me excited," Kaeberlein says, "was realising that we could not only understand the biology of ageing in dogs, but also apply interventions



CLOCKWISE FROM TOP LEFT Dr Rachel Melvin (in red) signs her Belgian malinois Jinx up to the Dog Aging Project's longitudinal study; Prof Daniel Promislow and Frisbee; Prof Matt Kaeberlein with Chloe; Cancer cells, as seen under an electron micrograph – the disease becomes more likely the longer humans or dogs age

that have already been shown to slow ageing, extend lifespan and improve healthspan in mice. Almost certainly, some of them will work similarly in dogs."

"I'm a dog person. I've always had dogs," says Kaeberlein. "Obviously, I wanted that for my dogs. I want that for everyone else's dogs, too."

A big part of the Dog Aging Project is what's called a longitudinal study, which basically means researchers track the same dogs over time to understand how they age. By collecting detailed questionnaires from the owners of 50,000 participating pooches, the team is already uncovering some fascinating insights into what helps dogs stay healthier for longer.

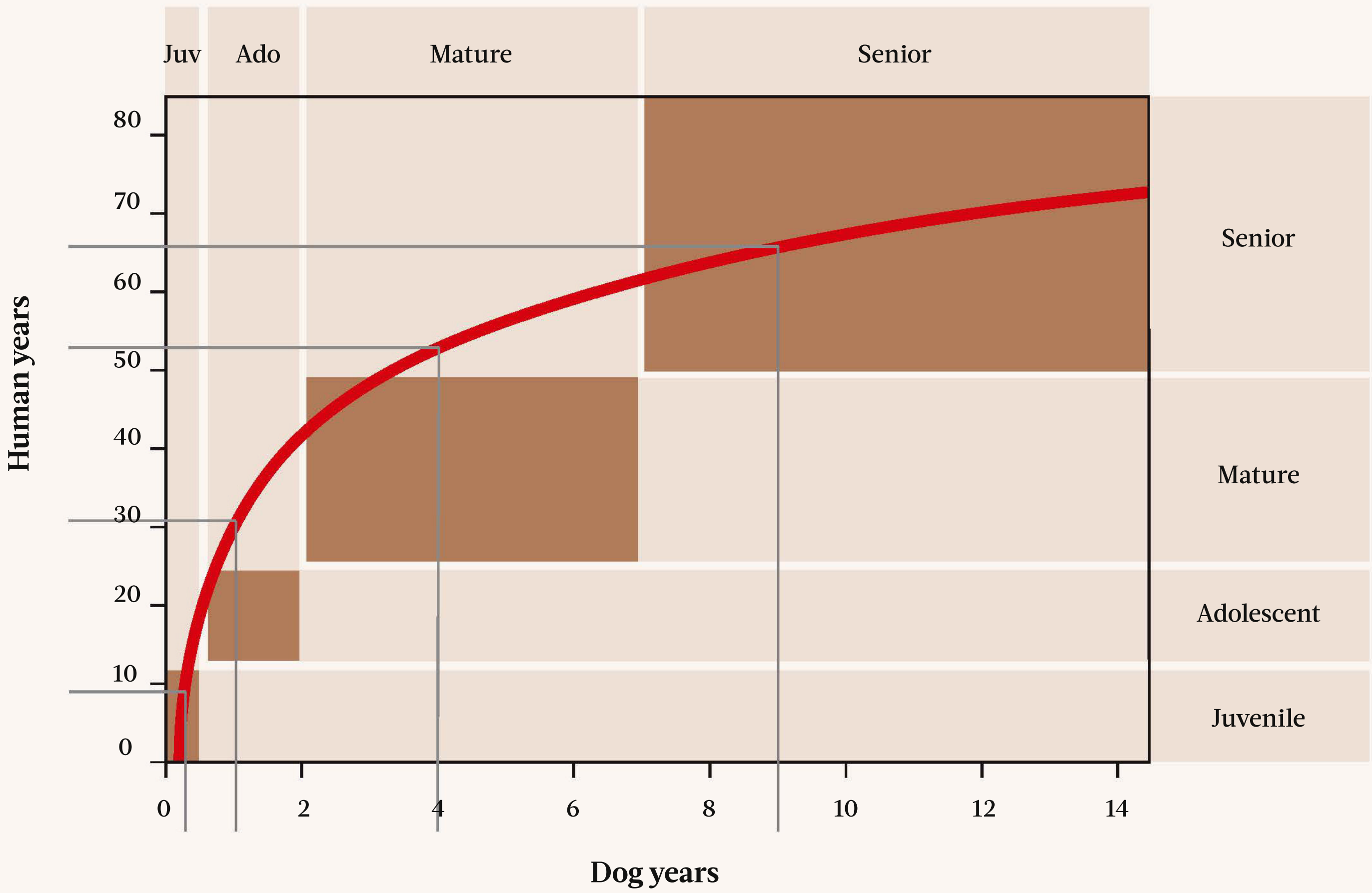
One early finding: how often dogs eat may influence how long they live. "It turns out that dogs fed once a day are at a lower risk of developing several age-related conditions," Kaeberlein says. "It was completely not what I expected! I've never been a big believer in time-restricted eating as a longevity intervention."

However, because this is an observational study, it's hard to untangle cause from effect. Maybe less frequent feeding leads to better health, or maybe dogs in poorer health are simply fed more often, perhaps to take medication. "But it's still a really interesting observation that seeds a whole bunch of potential studies in the future," says Kaeberlein.

So, does this mean you should shun breakfast and lunch in favour of one supersized supper? Perhaps not. One human trial of the 'one meal a day diet' has suggested it can lead to slightly worsened measures of health – plus, it's not exactly easy to stick to (you'll likely be starving by mid-afternoon).

Still, the Dog Aging Project's findings are worth watching. If future research (including a proper randomised trial) confirms that less frequent feeding really does boost canine health, scientists could dig into the biological reasons behind it. That could eventually lead to a pill that mimics the benefits in humans – no extreme diets required.

Intriguingly, this very drug may already exist – it's called rapamycin. Discovered in bacteria from a soil sample collected on Easter Island (aka Rapa Nui) in the South Pacific, rapamycin is a molecule that prompts cells to perform a kind of spring-clean: clearing out old components and replacing them with new ones. This process, called autophagy, is also



triggered by fasting and has been linked to increased longevity in a wide range of organisms. Scientists have used rapamycin to slow ageing in species as varied as yeast, worms, flies, mice and even tiny primates known as marmosets.

Dogs could be next. That's the goal of TRIAD (the Test of Rapamycin In Aging Dogs), a clinical trial from the Dog Aging Project aiming to begin in 2026. The study plans to enrol 580 dogs, treat them with rapamycin for one year and then monitor them for another two years to assess the drug's long-term effects. (Two smaller, shorter studies have already made sure that it's safe for dogs and hinted at benefits for older hounds' heart health).

"I think it's a better than 50/50 proposition that rapamycin increases lifespan and improves health in dogs," Kaeberlein says. "Whether we have the right dose and whether the duration of our clinical trial is enough to show the effect – that's a different question. But it wouldn't shock me if, in larger dogs, you could get a 20-plus-per-cent increase in healthy lifespan."

With rapamycin already showing promise in humans (the drug was recently ranked by scientists among the top five drugs most likely to extend healthy lifespan), it's easy to see why he's so optimistic. Still, it's the upcoming canine trial that may offer the clearest reason yet to be excited.

TRIAL AND TERRIER

Slowing ageing in dogs isn't just an academic pursuit: almost half of US households have a dog and Americans spend $140bn (£105bn) on their pets annually, meaning there would be plenty of buyers for a drug that could keep them healthy for longer.

That's why several startups are vying to collar the dog longevity market. Likely leading the pack is Loyal, which has raised over $150m (£112m) since 2019 and whose experimental drug LOY-002 was provisionally approved in February by the US Food and Drug Administration (FDA) with a "reasonable expectation of effectiveness." This approval requires demonstrating that it's safe, but allows Loyal to take the medication to market while simultaneously running a clinical trial to determine if it works.

Testing a medicine for dogs is quite different from a human drug trial. For a start, the patients are much cuter, as Celine Halioua, founder and CEO of Loyal, jokes. But that's not its only unique feature. "Our clinical trial is unlike any other in the sense that we're not focused on treating a specific disease or ailment, but on extending healthy lifespan overall. It's the first FDA-concurred trial for a longevity drug for any species," she says.

Loyal's study has already enrolled 1,000 dogs, with another 300 on the way. Though the company is

ABOVE A graph showing an approximation of how much time humans and dogs spend comparatively in each phase of their lives

MARIA ARCOS/DOG AGING PROJECT X2, ALAMY, SCIENCE PHOTO LIBRARY

How old is your dog?

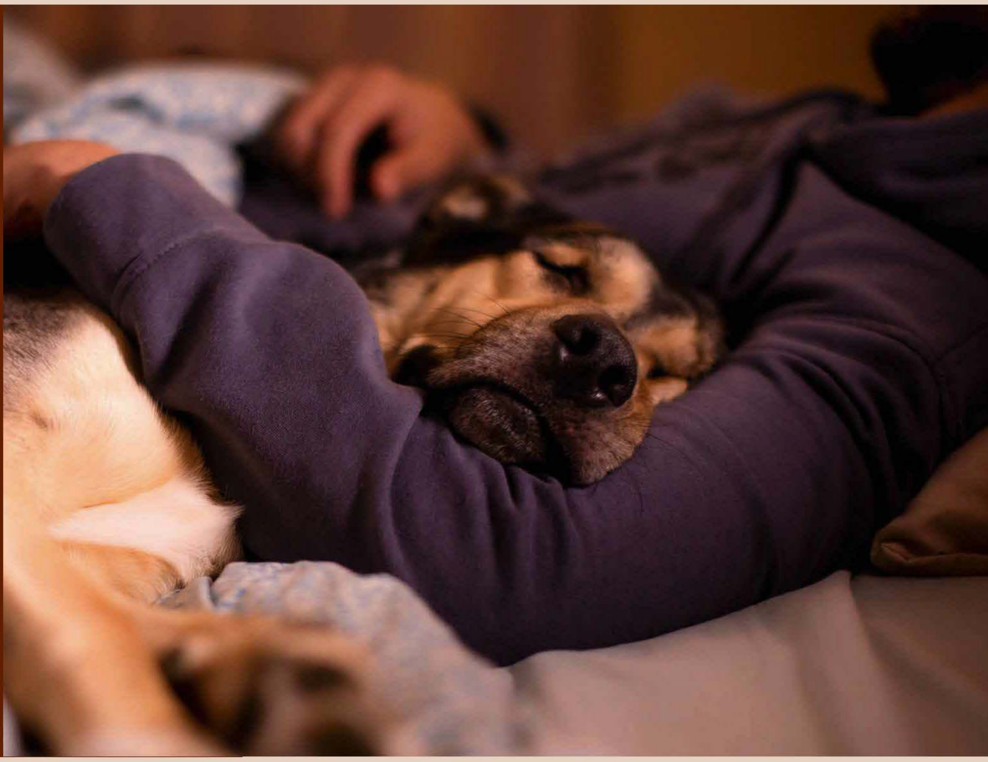
The classic rule for converting human years to dog years is to multiply by seven, so a three-year-old pooch would be 21 dog years old. But we now know that this is an oversimplification.

Researchers at the University of California San Diego measured the biological age of 100 labrador retrievers using an 'epigenetic age' DNA test, and compared results of similar tests in humans.

Their results hinted that labradors grow up faster than the seven-year rule would suggest, reaching the equivalent of 31 human years in their first 12 months. Thereafter, things slow down, with a 12-year-old lab being equivalent to a 71-year-old person. That's 13 years less than 12 × 7 = 84.

To calculate your dog's epigenetic age (this will be most accurate if your dog is a lab) whip out your phone calculator, put it into 'scientific' mode (we're doing science here, after all) and type:

$16 \times \ln(\text{your dog's age}) + 31$



ABOVE Sharing our environments and lives so closely for so long means dogs' microbiomes are closer to ours than those of the lab animals typically used in longevity studies, such as mice

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keeping exactly what's in the medicine under wraps for now, its website describes it as a "caloric restriction mimetic". This means it tricks the dogs' cells into thinking that the dog is cutting back on calories.

Dietary restriction has been linked to extending lifespans across the animal kingdom, from worms to monkeys, and a 2007 study reported that eating 25 per cent less could help labradors live 16 per cent longer compared to a normal diet. Loyal's hope is that mimicking this process with a drug could create a similar lifespan extension, but without actually needing to feed the dogs less.

Loyal's other drugs, LOY-001 and LOY-003, are designed specifically for big dogs – those over 18kg (40lbs). That's because they target a key biological difference between large and small breeds: a hormone called insulin-like growth factor 1 (IGF-1). IGF-1 plays a major role in regulating growth and has been linked to both body size and lifespan across the animal kingdom. Bigger dogs produce more of it, which could help explain why they tend to age faster than their smaller counterparts.

By reducing the level of IGF-1 in large dogs, Loyal is hoping the animals will live longer, healthier lives. If that turns out to be true, it could offer valuable clues about how IGF-1 affects ageing in humans too – and whether targeting it might one day help us live longer as well. Interestingly, scientists have already seen that humans who live past 100 carry unusual variants in their IGF-1 gene, which suggests a possible connection to longevity in people, too.

While concentrating on getting the dog drugs over the line for now, Halioua is keeping one eye on this grand prize: "I believe extending the lives of our best friends is worthy in and of itself," she says. "But Loyal's research could fundamentally change how we think about ageing in general, creating a new category for preventative medicine."

IN THE DOGHOUSE

Unfortunately, the story of dog ageing isn't all good news for dogs. Thanks to funding cuts in 2023, The Dog Aging Project has effectively stalled. "Most of the science has come to a halt," says Kaeberlein.

And it's not yet clear if more cuts are coming. The current administration has proposed a 44-per-cent cut to the National Institutes of Health (NIH) budget, which could scupper future canine anti-ageing studies.

For Kaeberlein, it's a massive missed opportunity. "There are 8–10 interventions that are safe enough that they can and should be tested in dogs," he says. "If somebody wanted to put between \$25m–\$50m (approx £18.5m–£37.5m) towards this, you could test 5–10 interventions in dogs and, in five years, figure out which ones slow ageing."

While we wait for a government, or a rich dog lover, to put up the cash, the Dog Aging Project is still looking for new 'pack members' for both its longitudinal study and the rapamycin clinical trial. Just head to dogagingproject.org to sign up your pooch.

Only US-based dogs can enrol for now, but Kaeberlein is "optimistic" that the project will go international "at some point in the future". If there's anything that can unite political factions and, indeed, the world in these tumultuous times, surely more healthy years for our dogs is a strong contender. **SF**

by **DR ANDREW STEELE**

Andrew is a Berlin-based scientist, writer and presenter. He is the author of Ageless: The New Science of Getting Older Without Getting Old *(Bloomsbury, 2020).*

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LIFE AT THE WORLD'S END

Harsh conditions and extreme isolation aren't the only threats facing scientists working in the Antarctic. They also have to worry about the potential danger they may pose to each other

by LIAM DREW

They knew the weather would be bad. But the three-person film crew, in Antarctica to document emperor penguins for a BBC documentary, decided to press ahead. "We wanted to film in these conditions," says Stefan Christmann. Footage of the birds in a blizzard would showcase this quintessential aspect of Antarctic life.

"The weather was more severe than we'd anticipated, but still manageable," Christmann says. But as the team journeyed back to base, conditions plummeted. Visibility dropped to about 2–5m (5–16ft). "We couldn't see anything," Christmann says. "We had to drive our ski-doos just with the GPS."

Until, that is, the battery in Christmann's GPS unit failed. He had to stop to replace it, knowing that stopping meant losing sight of his companions. Then, when he reached for his backpack, the wind blew one of his gloves clean off his hand.

"Something as stupid as this can get you into trouble," he says, recalling his struggle to retrieve new gloves and the replacement battery. "It takes a long time. You're standing there for five minutes and it feels like an eternity. You start fearing for your life."

Antarctica – Earth's highest, driest, coldest and windiest continent – is dangerous. The blizzards, hidden crevasses and icy landscapes, along with the risks of frostbite, hypothermia, snow blindness and dehydration, shape everything that happens there. Yet, having been asked about the stresses and pressures of life on a research station there, it's taken Christmann – a freelance wildlife photographer and filmmaker from Germany – 30 minutes to mention this life-threatening storm. He quickly dismisses it too: "Once you're back inside and everything is fine, I'd say it doesn't add to your overall stress level."

"Unless," he adds, "somebody did something that was completely stupid." This comment takes him straight back to his dominant theme: other people.

Christmann spent two one-year stints at Germany's Neumayer III research station. In the summers, the base was crammed with 70–80 people, sleeping four or five to a room, all working frantically in the year's most favourable conditions. "You don't have any privacy whatsoever," Christmann says. "Only when you're sitting on the toilet do you have time for yourself."

With work being physically and mentally exhausting, and the

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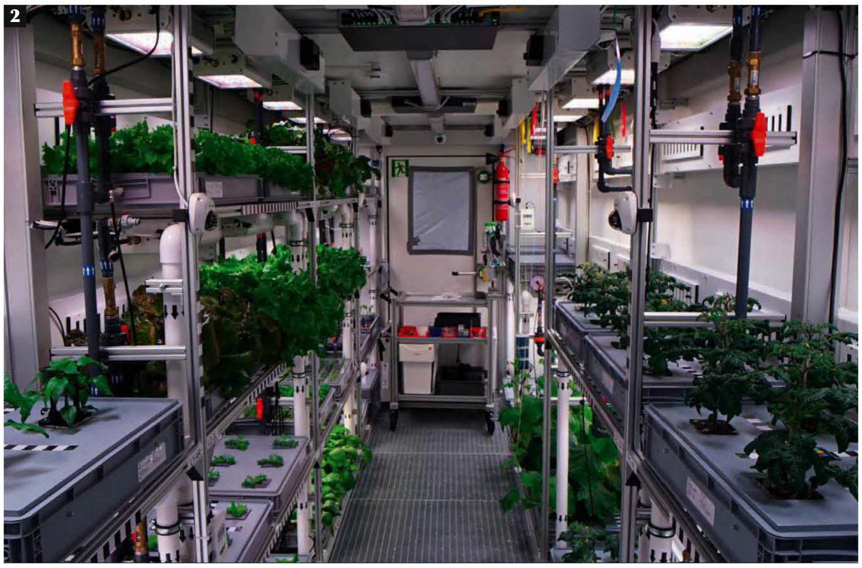

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Neumayer-Station

environment taxing, "you get to a point where you just want to be by yourself. That increases stress levels enormously."

Then, when summer turns to winter, 90 per cent of the staff leave and so-called "overwinterers" face seven long months with only each other for company. Factions and cliques form, and conflicts arise.

Christmann's experiences chime with recent news from Antarctica. In March, a researcher at a South African base physically assaulted and threatened to kill a colleague. The trigger was apparently a change to the station's work schedule. Other camp members pleaded to be rescued. But when the news broke, the perpetrator was being counselled and the small team looked set to remain in place until December.

"[The stresses have] very much changed over the history of people going to the Antarctic," says Aurelia Reichardt, station leader during summer seasons at the British Antarctic Survey's (BAS) Rothera Station. Since advances in housing and equipment mean that people's most basic needs are largely met, she says, other issues become more prominent. "I would say interpersonal challenges are the biggest stressors in Antarctic stations right now."

But while Reichardt acknowledges that conflicts occur on Antarctic bases – and that helping resolve them is a significant part of her job – she's never had to exercise her powers as a local magistrate. "Frank criminality," she says, "is an extreme outlier case."

A WORLD APART

There are currently 70 Antarctic research stations, operated by almost 30 countries. Bases tend to be microcosms of their mother countries (Rothera has tea breaks with biscuits and a roast dinner every Sunday, says Reichardt).

Most are dotted along the coast, a few lie further inland. Only half operate year-round and these all house drastically reduced crews in winter. By far the largest is the US's village-like McMurdo Station, which houses around 1,200 people in the summer and about 150 through winter. Several stations – including Rothera – have 160 or so summer occupants and 30–40 winter staff. The rest get progressively smaller, with winter crews often in the single digits.

The breadth of science done in Antarctica is vast. Astronomers, astrophysicists, biologists, climatologists, ecologists, geochemists and geophysicists, meteorologists, oceanographers and zoologists all study Antarctica's unique ecosystems, physical geography and climate – or take advantage of its pristine skies. The scientists live alongside the cooks,

1. Winters in the Antarctic mean the Sun spends most of its time at, or below, the horizon

2. Inside a botany lab at the Neumayer III research station

3. Germany's Neumayer III station can hold 70–80 people during busy periods

4. America's McMurdo Station is a sprawling village compared to other outposts

4

"PEOPLE THERE ARE MARKED BY ENTHUSIASM AND PASSION. IT'S NOT A PLACE YOU WIND UP IN BY ACCIDENT"

electricians, mechanics, plumbers and other technical staff who maintain the research stations and make life possible there.

Asked if there is an "Antarctic type", Reichardt says people there are marked by enthusiasm and passion. It's not a place you wind up in by accident.

Screening and selection processes vary considerably by country. The BAS uses a classic panel interview and sometimes practical job assessments, says Reichardt. They don't use psychometric screening. Likewise, Christmann didn't undergo psychological assessment, though he passed a full physical.

Prof Lawrence Palinkas, a medical anthropologist at the University of California, has studied people's experiences of Antarctica for 40 years. He says that pre-millennium, American recruits underwent an intensive two-day assessment, including interviews with clinical psychologists, but that screening became less rigorous in the 2000s.

Recruits also partake in pre-deployment training camps, learning skills such as mountain rescue and firefighting. These camps are also intended as bonding sessions for people who will soon live together. They're also a forum for station-running organisations to instil conduct expectations and to verse people in conflict resolution techniques or other psychological coping strategies.

PHYSIOLOGICAL CHALLENGES

Antarctic life presents numerous physical and physiological challenges. Not least, its extreme light-dark cycles. The main coastal bases aren't subject to six months of winter darkness as the South Pole is, but winter light remains limited, and for about two months, the Sun never breaks the horizon.

"There are natural psychophysiological changes that occur during the winter months," says Palinkas. Termed winter-over syndrome by researchers in 1971, he says the various mental and cognitive changes resemble a form of psychological hibernation.

"It often manifests itself as lethargy," he says. "You lose your motivation. At times, you lose your energy."

STEFAN CHRISTMANN X2, ALAMY, GETTY IMAGES

Some people gain weight even if they're exercising regularly. People can also become more forgetful or struggle with short-term attention.

Sleep disturbances are also part of this syndrome. "The disruption of thyroid hormones due to darkness and the cold weather contributes to those psychological or emotional symptoms," Palinkas says.

This led Palinkas to run a randomised clinical trial – possibly Antarctica's first. It showed that thyroid supplements and light therapy reduced symptoms of winter-over syndrome. These interventions have been incorporated into routine medical care there.

A UNIQUE SOCIAL WHIRL

Rebecca Kaiser, a PhD student in psychology and criminology at the University of Tasmania, studies the distinctive social norms of research stations. "I don't think that there's more criminal behaviour in Antarctica," she says. "But I think that the behaviour down there is different."

After interviewing former Antarctic residents, Kaiser wrote a paper whose title began by quoting a common mantra: What happens on the ice, stays on the ice. This saying influenced the thinking of Antarctica's residents.

Some curious behaviours were simply a matter of de-stressing. Often, you suddenly need to do something different, Kaiser says, "to run over to that corner of the gym, put your headphones on and dance like you're a mad person, or close yourself in the library and read three books in a row."

But, Kaiser says, most behavioural changes that people experienced – from ritualistically, communally watching TV shows they'd never normally watch, to partaking in group pranks or madcap swimming missions that bent safety protocols – are adaptations to the intense group-living situation, and are largely done in service of community building. "Your life can depend on that group of people," she says, "so fitting in is essential. Some things that were technically against the rules were done to keep the community's equilibrium and homeostasis safe."

Combined, these behaviours indicated a set of local norms, internally maintained. Within this context, group safety – and whether a person's behaviour threatened it – was the main red line according to how people's behaviour was collectively judged. If people cross that line, punishment often comes by way of social exclusion. "The community will kind of close themselves off to that individual," Kaiser says.

This can be a harsh price to pay. In an overwintering group that preceded one of Christmann's, someone was ostracised. "They actually took her out early," he says, "because, psychologically, she wasn't in a good state."

While there were schisms in Christmann's crews, the groups split more evenly. He agrees that safety decisions can be flashpoints for disagreements and also highlighted differing work ethics as being divisive.

Divisions lingered and amplified, Christmann says. The group, for example, voted on many decisions and opposing factions would sometimes vote against their own best interests just to frustrate the other.

5

5. The social proximity of life inside the Antarctic research stations can be suffocating, but contrasts starkly with the extreme isolation that can be experienced outside them

6. The conditions in the Antarctic make for a very challenging environment

7. Collaboration and social cohesion are vital given how dangerous life there can be

SEXUAL HARASSMENT

A culture of sexism was put into sharp focus in 2017, when American geologist and associate professor Jane Willenbring revealed the bullying and harassment she'd endured years previously in Antarctica. (Willenbring waited until she had tenure to speak out.)

Work that Dr Hanne Nielsen, an Antarctic governance scholar and Kaiser's PhD supervisor at the University of Tasmania, did around the time that Willenburg's revelations surfaced, highlighted numerous barriers to women working in Antarctica. These included biases against people with caring responsibilities; a lack of female toilet facilities and support for women menstruating; and often a shortage of protective clothing and equipment in women's sizes.

As well as this, there was "cultural sexism and gender bias, lack of opportunities and recognition, and unwanted male attention or sexual harassment."

A National Science Foundation (NSF) survey published in 2022 found that 72 per cent of women said sexual harassment was a problem. Tellingly, only 48 per cent of men and 40 per cent of the leadership, irrespective of gender, said likewise.

The NSF has since introduced a 24/7 crisis line to report sexual harassment and get support in dealing with it. Improving reporting mechanisms is a key step, says Nielsen, as are other practical moves, like putting spyholes in bedroom doors so people can see who is attempting to enter. But she says, "that doesn't stop the problem from happening."

What's required, she says, is cultural change and for "organisations to take it really seriously." And the onus shouldn't lie with whistleblowing victims. "If you put your hand up and complain, because access to Antarctica is highly mediated, there's a real risk of not being able to go back," she says.

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> **"WHAT CAN BE DONE IS TO KEEP SEEKING WAYS TO STACK THE ODDS IN THE STATION RESIDENTS' FAVOUR"**

Reichardt agrees. "It's a core task of an organisation like ours to constantly reflect on itself [and ask] are we doing enough?"

The BAS and other Antarctic programmes are now publishing guidelines and codes of conduct. This is simply a safety matter, say Nielsen and Reichardt. If women are threatened, Antarctica's fundamental culture of safety is failing.

"There's a lot of activity happening in this space," Reichardt says. "But more needs to be done."

EVER EVOLVING

On research stations, Reichhardt says, "It's difficult to try and manage [your mental health] when you have restricted ways of coping with things – you can't go out and walk your dog." In recent years, the BAS has installed multiple routes through which people can ask for and receive mental health support. For example, video calls with therapists are available.

While this is an example of how increased connectivity can improve life on research stations, Reichardt says it can also be a double-edged sword. "For some people, that daily phone call can be their lifeline," she says. "For others, it might become a pressure that builds."

Additionally, social media can bombard residents with reminders of what they're missing. But Reichardt thinks that people in Antarctica now being online has gone some way to puncturing the 'What happens on the ice, stays on the ice' bubble.

"What you find in these remote environments," Nielsen says, "is that it's a really heightened version of the culture that you'd find back home." When society at large strives to be more just to women, more sympathetic to mental health challenges and wrestles with the dangers of being more online, so too do those little pockets of very human, very socially intense, life dotted about the Antarctic wilderness.

People going to work long-term on these bases will likely always face unpredictability. "I don't think any two winters are ever the same," says Christmann. What can be done is to keep seeking ways to stack the odds in station residents' favour.

Palinkas says that screening programmes have traditionally focused on screening out the wrong sorts of people. And that perhaps more attention should be given to screening in people with the right traits to succeed there – such as introversion and being a good team player. Nielsen agrees; she's even studied the ways recruitment adverts may attract inappropriate people by containing images of people surrounded by penguins. "A lot of the time, that's not what it's like, especially in the winter," she says. In reality, "you have to be really good at sitting day after day under artificial lighting."

Reichardt is passionate about constantly improving the environment at Rothera and is eager to return. It's the community that keeps drawing her back. "It's incredibly rewarding to be part of the science mission," she says. "Everyone's working towards this goal of trying to further our understanding of the planet."

Christmann feels similarly. "Yes, there were some fights. Yes, there were some troubles," he says. "But these have been the two best experiences of my life." **SF**

by **LIAM DREW**

Liam is an author and award-winning journalist with a prior academic career in neuroscience research at UCL and Columbia University.

STEFAN CHRISTMANN X3

THE CONFI

Neuroscience may have finally uncovered the secrets of self-belief. And they're far more learnable than we thought

by JESS THOMSON

DENCE *TRICK*

ILLUSTRATION: JOE WALDRON

Somehow, we've seriously underestimated confidence. While most of us likely want more of it (only 16 per cent of us describe ourselves as 'very confident', according to a YouGov survey), many of us don't realise just how profoundly a bit more self-belief could change our lives.

Far from being just a trait that's useful for delivering TED talks or impressing at dinner parties, confidence has long been known to be a powerful predictor of life outcomes. Truly confident people tend to be healthier, happier and more resilient. They perform better in school, report greater job satisfaction and career success, build stronger relationships and are often more effective team players.

On the flip side, low confidence goes beyond occasional moments of self-doubt. It's associated with the fear of judgment, poorer mental health and even a higher likelihood of engaging in criminal behaviour.

In other words, psychologists have known for decades that confidence matters. A lot. Yet for a long time, its inner workings – the hows and whys of confidence – remained elusive.

That was before some bright neuroscientists had an idea. What if, they thought, brain-scanning techniques such as functional magnetic resonance imaging (fMRI) and electroencephalography (EEG) could uncover the brain networks that 'generate' confidence? Could we watch how these feelings impact our decisions in real-time? And the big question: could we discover whether confidence is an innate trait encoded in our biology, or a quality we can learn?

Prof Ian Robertson, a clinical psychologist and founding director of the Trinity College Institute of Neuroscience in Dublin, is one of the scientists asking exactly these kinds of questions. With the help of the latest technologies, he's been studying how confidence acts in our brains and bodies. And his core message is a reassuring one: confidence absolutely isn't something some of us are simply born with.

"You normally can't see inside the heads of people who seem effortlessly confident. But they're acting more confident than they actually feel," Robertson says. "Confidence is not about feeling certain that our actions will achieve our desired outcome.

There will always be some uncertainty. Instead, confidence is about effectively coping with the anxiety that this uncertainty produces."

He says that, in this way, confidence isn't a fixed trait, but rather a way of thinking and behaving that can be learned. And with the right approach, understanding and practice, "it starts to feel effortless."

WHAT MAKES CONFIDENCE?

There are two big things you should know about the neuroscience of confidence. The first is that it's anything but simple.

"Confidence isn't housed in a single part of the brain," says Dr Stacie Grossman Bloom, a neuroscientist at New York University who studies the brain mechanisms behind confidence and self-belief. "It's the result of a network of regions working together."

Some of the brain's key players in this network may sound familiar – the prefrontal cortex, for instance. Located just behind your forehead, this area helps you assess yourself, weigh options and make decisions – all essential when you're about to take a risk or face a challenge.

ILLUSTRATION: JOE WALDRON

"CONFIDENCE ISN'T JUST A FEELING, IT'S A LEARNED RESPONSE"

Then there's the amygdala, perhaps best known for its role in helping trigger emotional responses such as fear. But a well-functioning amygdala doesn't just sound your brain's alarm bells – it also helps you judge when things are *not* threatening, which is essential for establishing a sense of safety. "The amygdala can actually modulate emotional responses, which are deeply connected to feelings of confidence," says Bloom.

The second key thing to know about confidence in your brain is that it operates as a loop. Rather than a one-off spark, it's a self-reinforcing feedback system powered by action, reward and memory – a cycle that learns from success and strengthens your belief that you can do it again.

At the core of this loop is the brain's reward system and the neurotransmitter dopamine. You might know it as the 'pleasure chemical', but dopamine's full role is often misunderstood. Yes, it spikes when something good happens (like eating a great meal or having sex), but it also plays a crucial role in anticipation. Dopamine is released not only in response to rewards, but also in anticipation of them. In this way, it acts as a motivational signal, nudging you to repeat the behaviours that led to previous rewards and positive outcomes.

This process is part of what neuroscientists call 'reinforcement learning' – the brain's way of linking actions to results. When dopamine is released in anticipation of success, it helps strengthen the connection between what you do and the reward you expect.

That's where the hippocampus, your brain's memory hub, comes in. When you recall a moment where your actions led to success – like nailing a work presentation, for instance – the hippocampus helps reactivate the brain networks involved in that experience. You're not just remembering the event, you're reawakening the brain's 'confidence pattern', reinforcing your belief that you can succeed again.

In other words, confidence isn't just a feeling, it's a learned response. And the more your brain can draw on experiences of success, the more confident you'll feel next time you face a similar challenge.

"Success literally teaches the brain, 'This works – do it again!'," says Bloom.

THE WINNER EFFECT

You could be forgiven for thinking that all the above is just neurological smoke and mirrors masking the simple idea that past success builds future confidence. But that simple idea hides something powerful: the confidence loop doesn't just grow, it snowballs dramatically.

Enter the 'winner effect'. As Robertson explains, this phenomenon describes how winning once can actually make you more likely to win again, not just through improved skill or better odds, but because confidence reshapes the brain. Studies have observed this in tennis players, cyclists, financial traders and even animals: male mice that win a series of staged fights against weaker opponents become more likely to defeat stronger rivals later on.

“YOUR SMALL SUCCESSES MULTIPLY INTO PROGRESSIVELY BIGGER SUCCESSES. SO, THE GREATEST ENGINE OF CONFIDENCE IS SUCCESS”

“Confidence is like compound interest,” Robertson says. “Exponentially, your small successes multiply into progressively bigger successes. So, the greatest engine of confidence is success.”

But there’s more. Winning doesn’t just fuel future performance – it can also shape how the brain handles stress.

“Each competitive interaction causes your body to generate some cortisol, the stress hormone,” says Robertson. “At high levels, it’s toxic to the brain and the body.” However, confidence and winning can act as a kind of neural buffer against stress.

This accounts, Robertson argues, for how Oscar winners live on average five years longer than Oscar nominees, and Nobel Prize winners live about a year and a half longer than Nobel nominees.

“Because there are only very few people who get these accolades, their brains basically say, ‘you’re out of the rat race!’. Essentially, they no longer have to compete. They’re effectively liberated from all these little toxic cortisol secretions.” **SF**

by JESS THOMSON

Jess is a freelance journalist covering science, health, culture and lifestyle.

HOW TO GET MORE CONFIDENCE

What if you don’t have an Oscar at home? Or you can’t remember the last time you felt confident? No problem. You can still tap into the winner effect to start building confidence from scratch. Here’s how.

1. ACT THE PART

It’s the kind of advice you’ve likely heard from an Instagram ‘charisma coach’, but surprisingly, there’s real science behind the 'fake it ’til you make it' mantra.

“Faking it is absolutely central to confidence,” says clinical psychologist Prof Ian Robertson. “Taking action in spite of feeling anxious can activate the ‘success mechanisms’ in your brain.”

Robertson suggests thinking of yourself as an actor in a play, with your character being ‘Confident Person’. Speak up in a meeting the way Confident Person would, hold eye contact, take up space. Eventually, your body starts to believe that you are Confident Person and the behaviour comes more naturally.

“This feels fake because there’s a discordance between your behaviour and what you feel,” Robertson says. “But all confidence feels fake at the beginning because confidence is a series of habits of thinking and behaviours. It’s only once you’ve done it 100 or 200 times that it starts to feel effortless."

In short, you might not feel much of a difference after your first attempt at faking confidence, but each time you pull it off, even in a small way, it counts as a win. And over time, those small wins build into real, lasting confidence.

“Confidence is a skill, not a fixed trait,” adds neuroscientist Dr Stacie Grossman Bloom. “Start small. Set goals that are realistic, achieve them and take the time to consciously celebrate your wins. This isn’t self-indulgent – it’s neurological training.”

ILLUSTRATION: JOE WALDRON

2. REFRAME ANXIETY

Trying to feel confident before that big meeting, but your nerves are taking over? Instead of suppressing those jitters, try reframing them as their close emotional cousin: excitement.

"Any situation that activates the sympathetic nervous system – our fight-or-flight response – can be interpreted in different ways," Robertson says. "And that interpretation shapes the emotion you experience."

In other words, you have more control than you think. A racing heart, dry mouth, and churning stomach might scream anxiety in one context, but in another they can signal readiness or excitement. It's the same physiological response, just seen through a different lens.

Research backs this up. In one 2014 study, participants were asked to say "I'm excited" before a stressful performance task (karaoke singing, public speaking or a maths challenge). Compared to those who said "I'm anxious" or received no instruction, the "excited" group felt more confident and performed better.

"Choosing to adopt a 'challenge mindset' – focusing on the potential rewards instead of possible failures – actually puts you in a confident state," Robertson adds. "And that mindset makes success more likely."

3. VISUALISE THE WIN

Similar to acting confident, visualising yourself confidently handling a conversation with the in-laws or sinking a hole-in-one can replicate the effects of real past successes.

That's because, as research has found, the brain can't accurately tell the difference between a real memory and a visualised scenario. This means that imagining yourself succeeding can replace a lack of real successes and helps your brain to build confidence.

"We can actually train our brains the same way we build muscle," says Bloom. "Techniques like visualisation – mentally rehearsing a successful outcome – activate many of the same neural circuits as real experience. Similarly, regularly challenging yourself in even small, achievable ways trains the brain to associate effort with success."

Better still, frame your visualised success in terms of your values. For instance, imagining yourself doing well in a job interview isn't just about landing the role – it's about what that success means to you. Maybe it's being able to support your family, having your talents appreciated or just proving you can rise to a new challenge.

"When you reflect on your values and strengths, you engage areas of the brain linked to motivation and reward," Bloom says.

4. SHORT-CIRCUIT THE SPIRAL

Even if we manage to play the role of the Confident Person throughout a party or meeting, many of us still go home and binge-watch our mental blooper reels, convinced we said something weird, cringey or catastrophically stupid.

That post-event anxiety isn't just uncomfortable, it can actually ramp up stress in the brain. Overthinking social interactions triggers the release of noradrenaline, the brain's fight-or-flight chemical. The more you stress, the more you overthink. And the more you overthink, the more noradrenaline you produce and further down the neurochemical doom spiral you go.

"Too much noradrenaline will impair your ability to think clearly. You'll very easily go down rabbit holes, get things out of proportion and not be able to think clearly," Robertson says.

However, if you adopted the actor's mindset discussed above (see 'Act the part'), there's a good chance that's exactly how you came across. Even if you felt like a mess on the inside, other people likely saw someone who was composed and self-assured.

"You're beating yourself up for little reason," Robertson says. "But if I asked the people at that party what they thought of you, most of them would probably say, 'Oh yeah, she was great – really confident!'"

In other words, confidence is first a performance, then a feeling. And consider this your stage cue.

ARE WE ALIENS?

Panspermia, the idea that life on Earth began elsewhere, among the stars, has long been controversial. But new results have brought it back into the limelight

by **JONATHAN O'CALLAGHAN**

Where did life on Earth begin? That sounds like a relatively straightforward question. Surely life on Earth began… well, on Earth, right? We know this planet had the right conditions for life to arise, and we can see evidence stretching back more than 4 billion years, almost to its formation. An origin on the planet seems like a simple answer.

Yet for years, some scientists have favoured an idea that life didn't start on Earth, but elsewhere in the cosmos. In this scenario, life (or at least the ingredients for it) would have been delivered to Earth on comets or asteroids, seeding the planet with inhabitants – a process called panspermia. If it occurred, it could – and arguably should – have taken place on other planets too, perhaps suggesting alien life is common in the Universe, and maybe even hinting that we ourselves were originally aliens to the planet we now call home.

That idea is gaining traction thanks to a pair of missions – NASA's OSIRIS-REx and Japan's Hayabusa2 – that, in the past few years, have returned rocks from asteroids back to Earth. Analysis of those samples suggests that some of the building blocks of life are present in the asteroids, raising the prospect that those same building blocks, and perhaps even life itself, could have been delivered to Earth.

ILLUSTRATION: OLLIE HIRST

It's "absolutely" plausible, says Dr Jason Dworkin, project scientist on the OSIRIS-REx mission at NASA's Goddard Space Flight Center in Maryland. "Early Earth had a bombardment of material."

When such an idea was first proposed decades ago, "everybody laughed," says Prof Paul Davies, a theoretical physicist and astrobiologist at Arizona State University. "Now we can look back and say they contained a germ of truth. They weren't totally crazy." So where are we right now with the idea and what does the future hold?

LIFE BEYOND EARTH

The origins of panspermia date back many years, but it was popularised in the 1970s by the British astronomers Sir Fred Hoyle and Prof Chandra Wickramasinghe in their book *Diseases from Space*. In it, they suggested that certain diseases, such as influenza, could have originated from beyond Earth.

The book wasn't well-received. "It sort of pushed Hoyle off the edge of the scientific community," says Davies. "He was widely regarded as having become crazy in his old age."

One of their ideas was that asteroids and comets could have been incubators for life, being full of organic material that could have been life's building blocks. As the objects orbited a star, they would evaporate, releasing the material held inside, which could seed planets in a solar system, such as our own. Such an idea remains controversial today. "I'm still very sceptical about that particular scenario," says Davies.

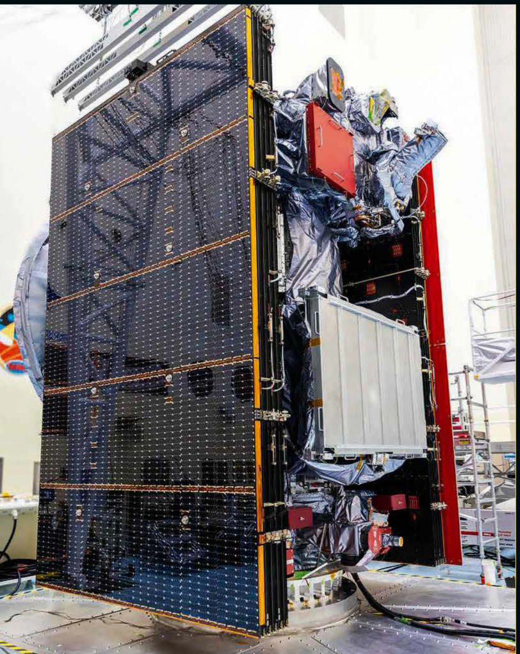
However, the possibility that asteroids and comets could contain the building blocks of life (and perhaps even primitive microbial life) and directly delivered to planets became more alluring. The idea reached a fascinating peak in 1996 when scientists said they had found traces of microfossils of bacteria inside a meteorite from Mars that had landed in Antarctica a decade prior. Known as Allan Hills 84001, the meteorite sparked wild claims that alien life had originated on Mars and could have been transported to other planets, such as Earth.

Such was the clamour around the rock that it prompted President Bill Clinton to make an announcement from the White House Rose Garden on the significance of the discovery. "Today, rock 84001 speaks to us across all those billions of years and millions of miles," he said. "It speaks of the possibility of life. If this discovery is confirmed, it will surely be one of the most stunning insights into the Universe that science has ever uncovered."

The signs of life in the meteorite were later refuted and today it's thought that non-biological processes led to the shapes inside the rock being misidentified as microfossils. Nonetheless, the announcement had a wide-ranging impact at the time, particularly for Davies, who, in January 1996, had suggested at a conference in London that life could be transported between Earth and Mars or vice versa. "There were very few people prepared to take what I was saying seriously – I was even denounced at the conference banquet," he says. "And then I was rescued by none other than Bill Clinton."

Mars actually could have been a good place for life in the Solar System to begin, says Davies, because it's smaller than Earth and would have cooled quicker following its formation 4.5 billion years ago. "So it was ready for life sooner," he says. Today, we can see evidence that

> "THERE WERE VERY FEW PEOPLE PREPARED TO TAKE WHAT I WAS SAYING SERIOUSLY"



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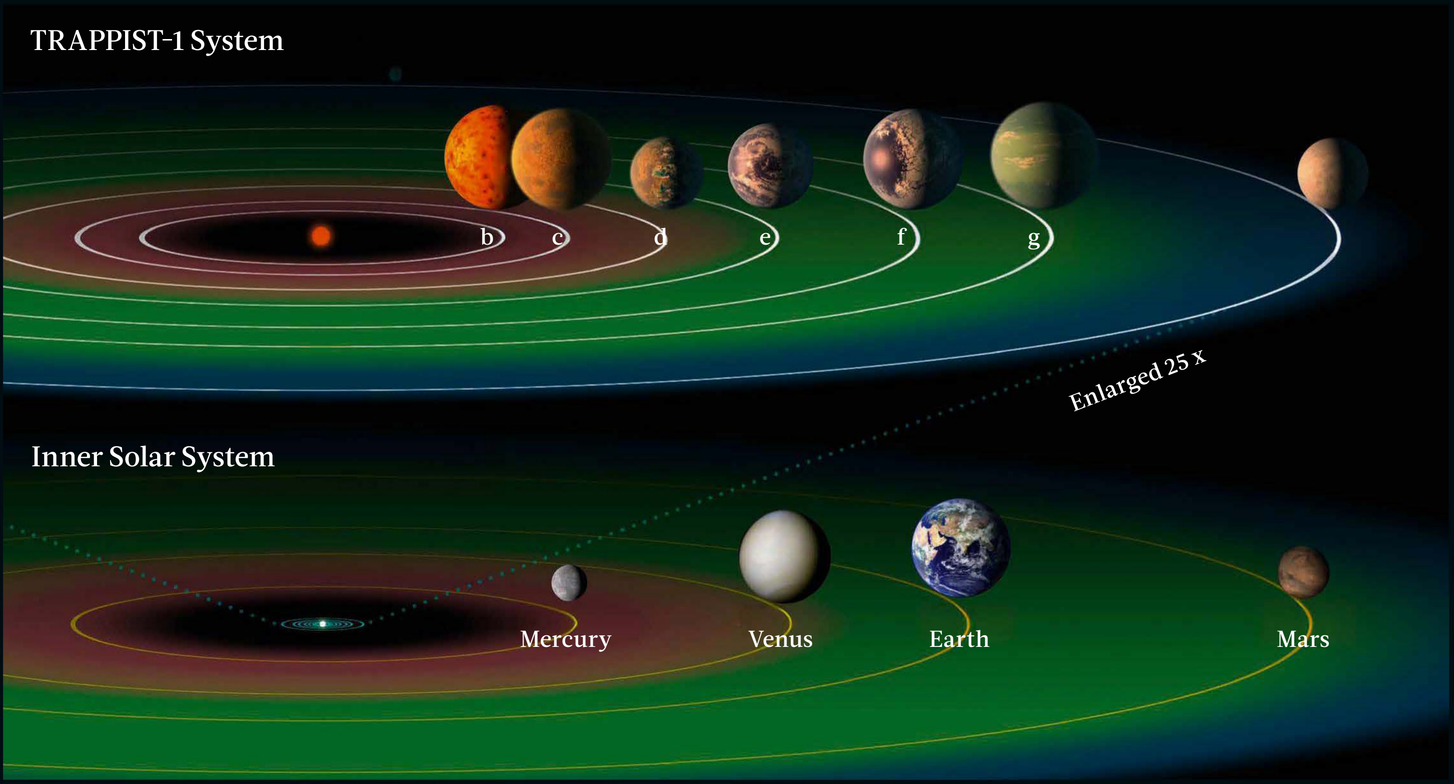


Mars was warm and wet, with lakes, seas and rivers on its surface about 3–4 billion years ago, but the possibility that life was present there remains an unanswered question.

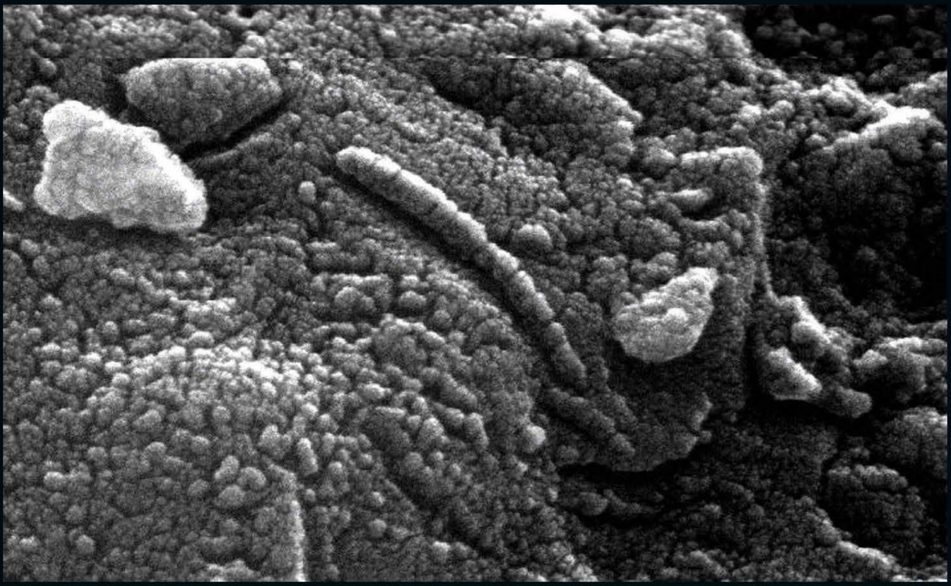
The fact that we have found Martian meteorites on Earth, though, shows that material can be transferred between the planets by impact events. Could it be that life actually did start on Mars, or elsewhere, before being transferred to Earth?

FAR LEFT NASA's Europa Clipper spacecraft is now on its way to Jupiter's moon to investigate the ocean beneath its icy surface

LEFT NASA held a press conference on 7 August 1996 to announce the discovery of microfossils of bacteria inside the Martian meteorite named Allan Hills 84001

ABOVE A scaled illustration of how the span of the TRAPPIST-1 solar system compares to ours

BELOW The microscopic structures in the Allan Hills 84001 meteorite that were thought to be bacterial fossils



SPECIAL DELIVERY

In our Solar System, the distance between the planets is quite large. That makes the chances of material being blasted off one world by an impact and drifting to another relatively slim. On Earth, of the 75,000 or so known meteorites, only about 300 are confirmed to have come from Mars. No meteorites from Venus have been found on Earth, nor from Mercury.

The possibility of transferring material between worlds is more promising in other solar systems, however. In 2017, planetary scientist Prof Fred Ciesla at the University of Chicago and colleagues suggested that for one system in particular, called TRAPPIST-1, the idea was particularly encouraging. In this system, which lies about 40 light-years from Earth, seven Earth-sized rocky planets orbit a star much smaller than our Sun, called a red dwarf. But they're arranged in much tighter orbits than the planets of our Solar System – all of the TRAPPIST-1 planets would fit inside the orbit of Mercury.

That should make the transfer of material between planets in that system more frequent, says Ciesla. "It's a very compact

OFF
MAIN MOM
TALK

NASA/GETTY IMAGES

"COULD ROCKS FROM SPACE HAVE SUBSEQUENTLY CARRIED THE INGREDIENTS OF LIFE TO EARTH?"

system," he says. "So the efficiency of something being launched from one to the other is much greater."

In their 2017 work, Ciesla and his colleagues suggested that the prospect of lithopanspermia in the TRAPPIST-1 system – where life itself is transported between planets – was plausible. The team calculated that 10 per cent of material ejected from a habitable zone planet in the TRAPPIST-1 system would reach another habitable zone planet in just 100 years. "We conclude that transferring solids between habitable zone planets in TRAPPIST-1 is up to [10,000–100,000 times] faster [than our own Solar System]," they wrote.

If the transfer of life-bearing rocks between the worlds of our Solar System is somewhat unlikely, what about another type of delivery – not from other planets, but leftover material around the Sun? Many millions of asteroids and comets orbit the Sun today and we know that these periodically hit planets. In fact, Earth's seas and oceans are thought to have originated from water delivered by these bodies, following a molten phase after a collision with a Mars-sized object that created the Moon around 4.5 billion years ago.

That makes asteroids and comets a potentially preferable place for the building blocks of life to arise in the Solar System. "Earth went through a tremendously dramatic event and the entire planet melted, so all of the early organics were lost," says Dworkin. Could rocks from space have subsequently carried the ingredients of life, or even life itself, to Earth? Once deemed implausible, recent results from two spacecraft are now suggesting that might well have been the case – and the race is on to find out for certain.

NO PLACE LIKE HOME

In December 2020, a spacecraft called Hayabusa2 from the Japanese space agency (JAXA) returned to Earth with about 5g (0.1oz) of samples it had collected from an asteroid, called Ryugu, more than a year prior. The spacecraft had fired a ball bearing-sized projectile into the asteroid, kicking up material into a collector and returning it to Earth for a landing in the Australian outback.

Three years later, in September 2023, a NASA spacecraft called OSIRIS-REx followed suit with its own samples from an asteroid called Bennu. Its extendable arm had been able to gather much more material than its Japanese counterpart, using a burst of nitrogen gas to scoop up more than 120g (4.2oz) of material. The samples touched down in the Utah desert inside a capsule.

Results from both missions have now shown that organic material, and the building blocks of life, are present on both asteroids, including carbon, ammonia, salts and more. "It's very clear that they do contain organics," says Davies. "It wouldn't have been a surprise to Fred Hoyle – he was saying all this in the early 1970s."

In January this year, scientists analysing OSIRIS-REx's samples said they had found 14 of the 20 amino acids that life on Earth uses to make proteins, and the basic constituents of DNA and RNA. The asteroid also seems to have been wet at some point in the past, with channels of water running through the rock. "We see evidence of veins of water that left behind salt deposits as it dried out," says Dworkin. "Think of it as mud."

Noticeably absent, however, is life itself. Bennu is thought to be the fragment of a larger asteroid that came from the outer Solar System, which begs the question, "What was Bennu's parent body missing that Earth had?" says Dworkin. "We know that the salts formed around room temperature, so it was a mild environment," heated by radioactive isotopes in the asteroid. "It was an environment you would expect maybe would be good for life, but it didn't happen."

HAYABUSA2
JAXA

LEFT 382kg (842lbs) of lunar samples were returned during NASA's Apollo missions, but no signs of life have yet been found in them

TOP RIGHT The OSIRIS-REx capsule returned to Earth containing samples of asteroid Bennu in September 2023

RIGHT A model of the Hayabusa2 probe Japan sent to collect a sample from asteroid Ryugu

Studies of the OSIRIS-REx samples are in their infancy. "We've only looked at about 14 per cent of the total samples," says Dworkin, with scientists only planning to look at about 25 per cent in total for the time being. "The other samples are being held for years so that people not yet born can use techniques not yet invented to answer questions we haven't even thought of," he says.

But the findings so far suggest that just having the right conditions and ingredients for life doesn't mean you'll necessarily create life. "It's got to be harder than just mixing the chemicals together, otherwise life would have formed on Bennu," says Dworkin. "Bennu is a pantry full of ingredients, but it wasn't quite the right conditions to make a cake. On Earth, we have cake and we don't know why."

SEEKING ANSWERS

There also remains the possibility that the transfer of life isn't limited to within worlds of a single solar system, but perhaps between stars. We've found two objects passing through our Solar System – 'Oumuamua in 2018 and Comet Borisov in 2019 – that were moving so fast they must have originated elsewhere. Could life, or its building blocks, survive the journey on such a body to seed worlds of different stars?

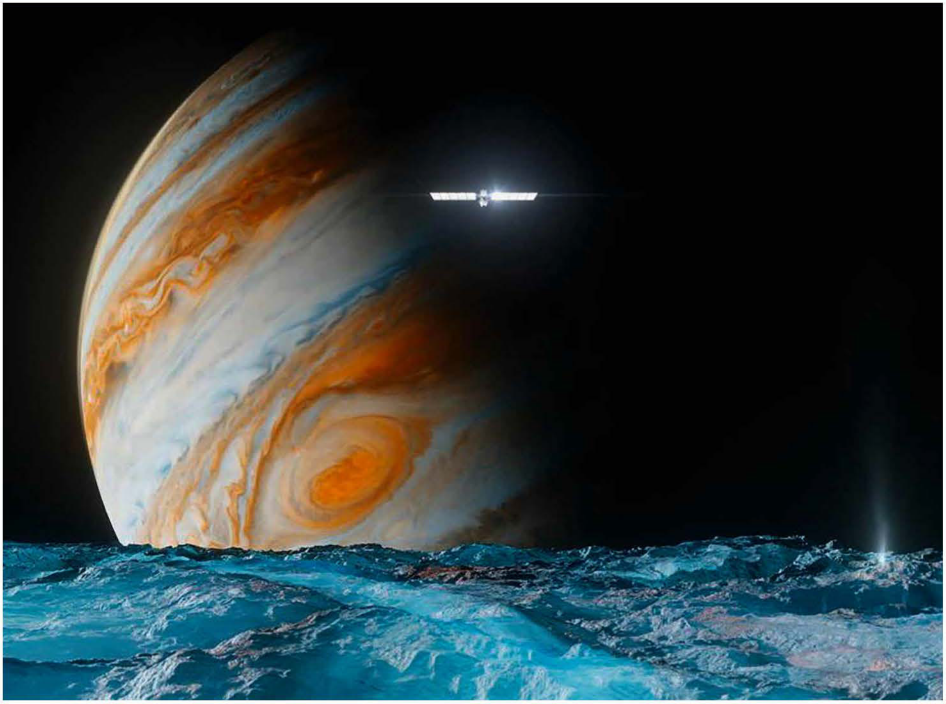
"The fact we're finding that stuff can be kicked out of one planetary system and make its way to another shows that this isn't limited to just within one planetary system," says Ciesla. "There's merit to the idea of life making its way from one planetary system to another."

The odds of a life-bearing rock making its way across interstellar space and hitting another planet to seed it with life seem slim, however. "When you put the numbers in, it looks exceedingly unlikely," says Davies. More likely panspermia is "restricted to within one planetary system unless there are exceptional circumstances," he says.

Whether life itself, not just the building blocks of it, could survive a journey between stars is also uncertain. "There are some species that can lie dormant for a long period of time and still survive," says Ciesla. "There's a potential there, but it isn't something people are necessarily talking about."

More plausible is the spread of life within a single solar system, such as ours.

> "THERE'S MERIT TO THE IDEA OF LIFE MAKING ITS WAY FROM ONE PLANETARY SYSTEM TO ANOTHER"



NASA's Europa Clipper spacecraft is due to arrive at Jupiter's icy moon and begin studying it in 2030

NASA/JPL

In the future, Ciesla says he would like to see a mission return material from a comet, not just an asteroid, to tell us more. "Comets are just like asteroids, they're the building blocks of planets, but they form further out in the Solar System," he says. "Understanding the pieces that were available to be delivered to a potentially habitable planet is a question I'd be really excited to see us pursue."

Ongoing missions to Mars and the icy moons of Jupiter could give us further clues, too. NASA's Perseverance rover is on Mars right now, scooping up samples intended to be returned to Earth in the next decade. The hope is that those samples might contain evidence of microbial life that originated on Mars back when the planet was warm and wet.

Meanwhile, NASA's Europa Clipper mission will arrive at Jupiter in 2030 to tell us more about this intriguing moon that seems to have an ocean beneath its icy shell. "People have speculated that life could take hold there," says Ciesla. "The ingredients seem to be there. The question again is whether or not the recipe was followed."

What is certain is that the prospect of life beginning elsewhere in the Solar System seems increasingly plausible. With that, there are important implications for our origins – whether we were a fluke resulting from an ingredient-laden asteroid hitting Earth at just the right time – and the possibility of life elsewhere.

"We have to contend with the fact we really don't know where life began," says Davies. "And it's entirely likely it didn't begin on Earth." **SF**

By **JONATHAN O'CALLAGHAN**

Jonathan is an award-winning freelance science journalist based in the UK.

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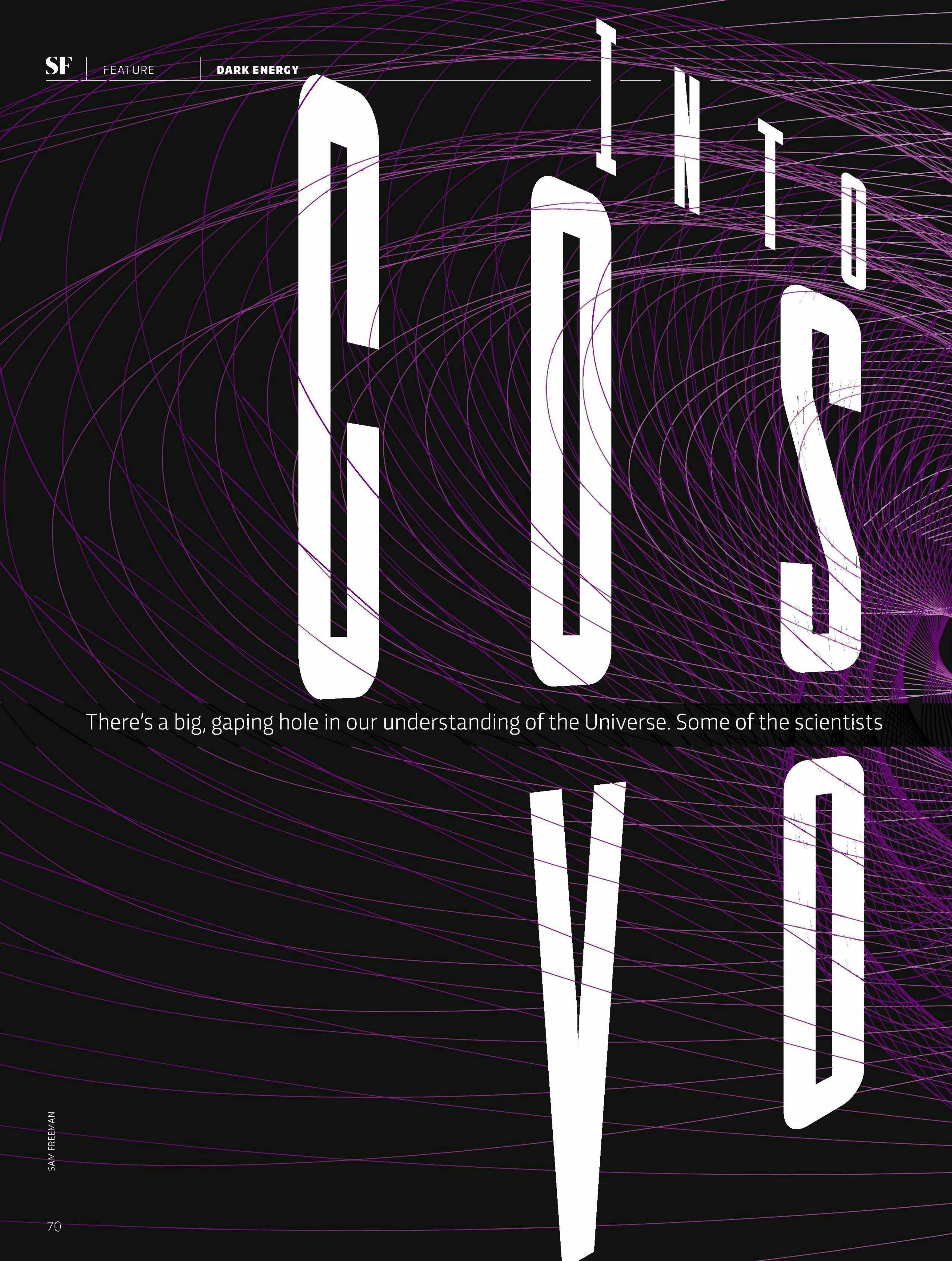

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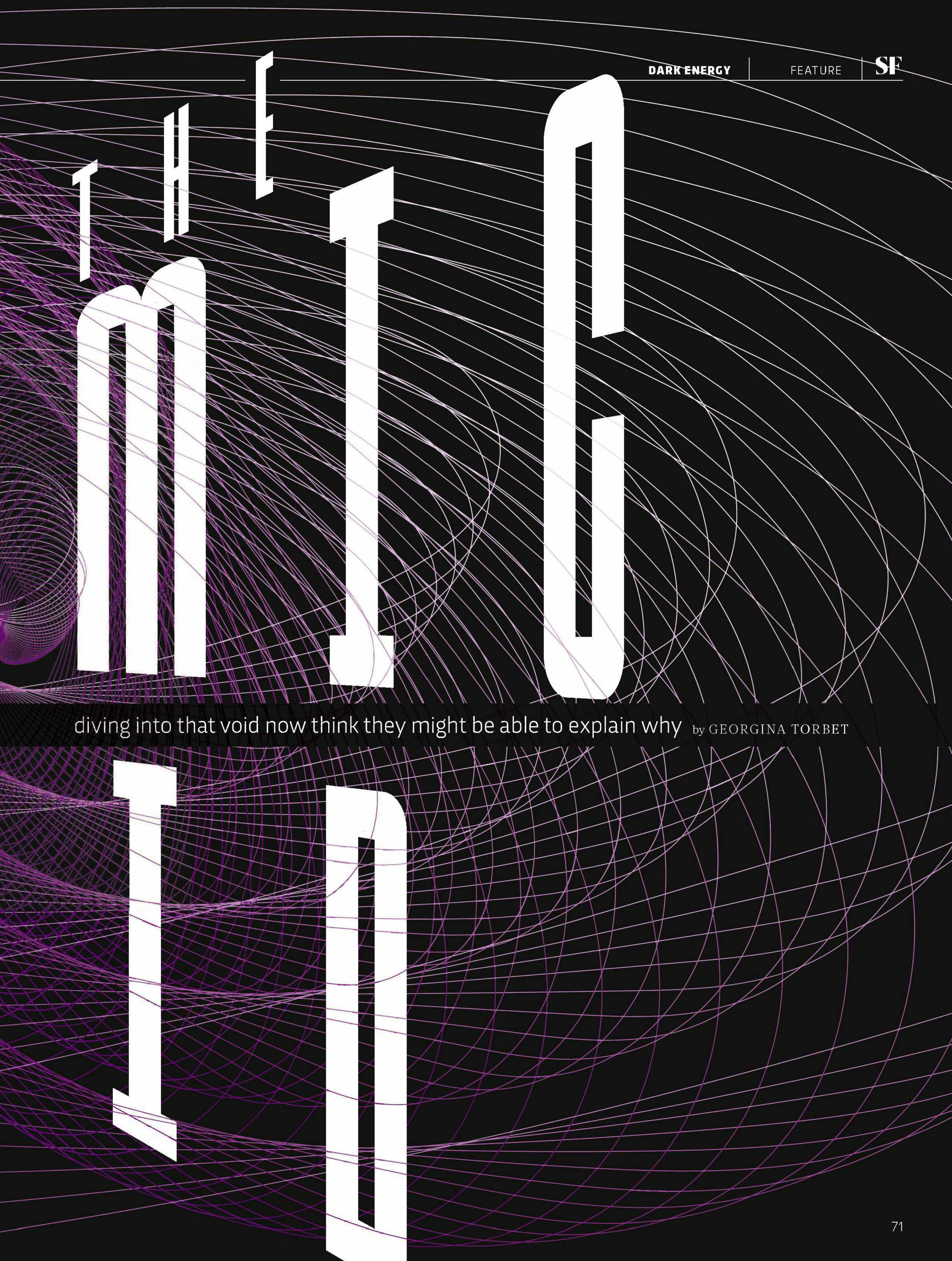
There's a big, gaping hole in our understanding of the Universe. Some of the scientists

SAM FREEMAN



THE MIC

IN

diving into that void now think they might be able to explain why

by GEORGINA TORBET

If you've ever read anything about cosmology, you'll have come across an astonishing statistic: all the matter around us, everything we see and touch, every star and gas cloud and planet, makes up just five per cent of the energy in the Universe. Of everything else, around 25 per cent is made up of dark matter, and the rest – a baffling 70 per cent of everything that exists – is dark energy.

Cosmologists say this must be the case because of the way the Universe is expanding. But it isn't just that the Universe is expanding; it's that the expansion is accelerating, and something must be driving that. We call that unknown force dark energy.

But there's a niche area of cosmology research that disputes this explanation. It argues that things appear to be expanding faster due to a mistake in our understanding of gravity. What's more, it also proposes that, maybe, dark energy doesn't exist at all.

FALSE ASSUMPTIONS

"The assumptions that we make in General Relativity in cosmology, basically, are that the Universe is very close to being the same everywhere and the same in all directions," says Hayley Macpherson, a General Relativity and cosmology researcher at the University of Chicago. Or, as cosmologists put it, the assumption is that the Universe is homogeneous and isotropic.

That makes sense when we're looking at the very early stages of the Universe, when it was small and dense, like a kind of primordial soup. But as the Universe evolved and expanded, it became more like what we see today – having some regions that are full of stuff, like stars and galaxies, and other regions that are much more empty.

So, do these assumptions of homogeneity and isotropy still hold? Obviously not in a literal sense – the Universe clearly doesn't look like soup – but are the assumptions good enough for cosmology? That's the key question affecting calculations.

Some theorists, like Prof David Wiltshire at the University of Canterbury, argue that these assumptions are so far off base that they're leading us to see the Universe in the wrong way. He started off working as a theoretical physicist, he says, and when he began looking into cosmology he wasn't particularly looking to criticise the Standard Model.

"It's just that the more I got into it and started speaking with people who actually do the observations, the more I realised that we're making huge simplifications," he says. "In looking for some average notion of isotropy and homogeneity, we're really assuming the answer rather than trying to explain it."

In his view, if you take Einstein's work seriously, you need to think of the expansion as something that's dependent on the 'clumpiness' of the Universe.

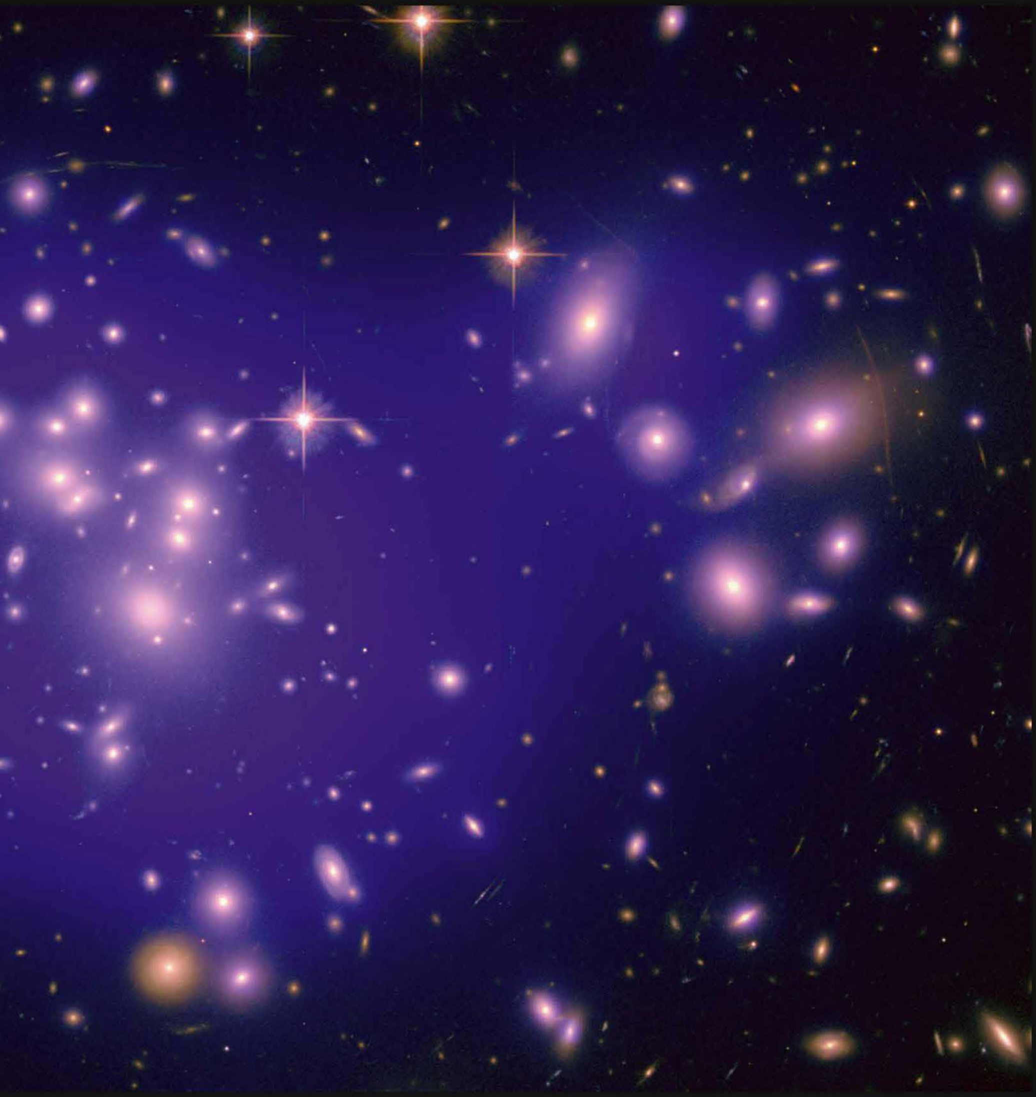
Gravity slows down time, so time passes differently in regions of the Universe with more matter than in parts with less matter. Different parts of the Universe will expand at different rates based on how much stuff is in them – that is, whether you're looking at a bunch of galaxies or a void.

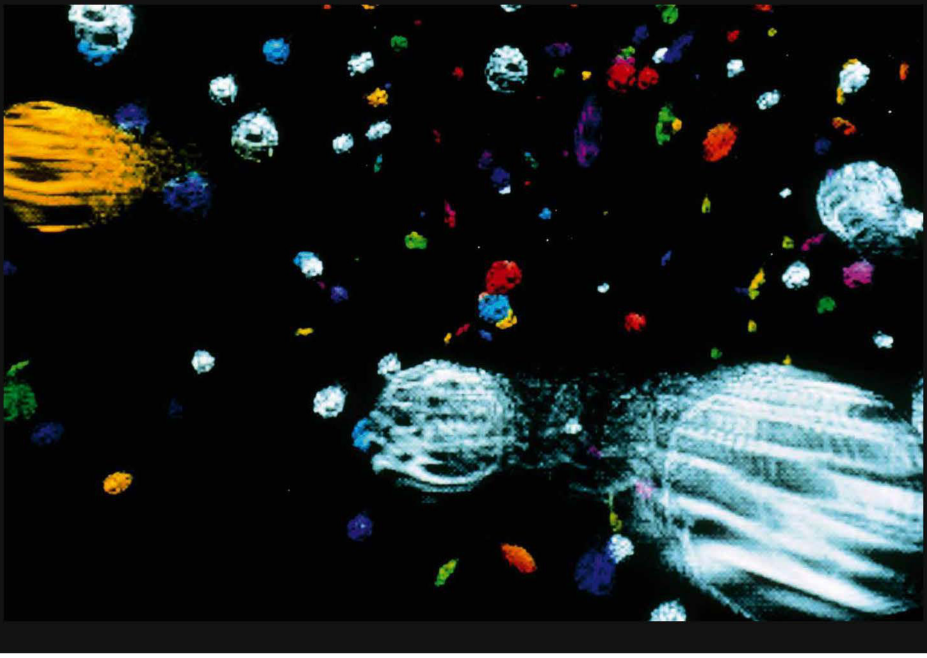
ABOVE Plotting the warping effects on the light from the galaxies in the Abell 1689 cluster has enabled scientists to infer the distribution of dark matter in the region (in blue)

RIGHT A visualisation of the early Universe, as a quark-gluon soup, during the initial moments after the Big Bang

And so perhaps we don't need the concept of dark energy at all. Perhaps the expansion of the Universe only looks like it's becoming faster, because we're looking at voids where the expansion appears faster, rather than areas with galaxies in them where the expansion appears slower. Perhaps it's all just the result of the counterintuitive effects of gravity on time.

"It really is saying, Right, there's this effect in Einstein's theory, which we've not thought of before'," Wiltshire says.





HUBBLE SPACE TELESCOPE, SCIENCE PHOTO LIBRARY

A STORY WITH MISSING PARTS

Mainstream cosmologists wouldn't deny that the Universe is inhomogeneous, or that there are simplifications built into the Standard Model. They mostly work with a version of General Relativity that makes use of a term Lambda, also known as the cosmological constant, which makes the equations of General Relativity work for an expanding Universe. On the whole, that model has been good enough for decades of productive work.

"We have this sort of vanilla description of the Universe, this minimal lambda CDM cosmological model that, for about 25 years since the discovery of dark energy, has done a remarkably good job at predicting most observations," says Jessica Muir, a dark energy researcher and assistant professor at the University of Cincinnati. "But we don't think it's the whole story."

There are many oddities in the Standard Model of Cosmology. There's the Hubble Tension, in which the acceleration of the expansion of the Universe seems to be happening at a different rate depending on what method you use to measure it. There's also something about the distribution of bright radio sources, called quasars, that doesn't seem to fit with the way we think the Universe is expanding. This is known as the quasar dipole anomaly.

But perhaps the biggest issue facing the Standard Cosmological Model – at least, the thing that most people struggle to wrap their heads around – is that we know almost nothing about the dark matter and dark energy that make up the majority of the Universe.

"There are things in our model that don't make sense," Muir says. "It's not very satisfying that we don't know what 95 per cent of the Universe is made of."

The fact that the current model is unsatisfying in some ways doesn't necessarily mean it's wrong, though. The difficult equations of General Relativity have certainly been simplified with assumptions to make them usable, but most cosmologists say that any effects these assumptions have are so small that they're likely unimportant.

"It would be very exciting if we say, 'Oh, we missed this thing, and it turns out we don't need a mysterious substance that has negative pressure and that makes up 70 per cent of the mass and energy in the Universe'," Muir says.

But when it comes to questioning the assumptions made about General Relativity, "Those assumptions have already been checked pretty rigorously, to the extent that I don't feel particularly convinced that the cosmological constant isn't needed," Muir says.

BUILDING BETTER MODELS

So, why not put that concept to the test and find out how big the effects of these assumptions about General Relativity really are?

That's exactly what Macpherson is doing right now by creating simulations of the Universe that are based on a more complex description of gravity, without so many of the simplifications usually placed on General Relativity.

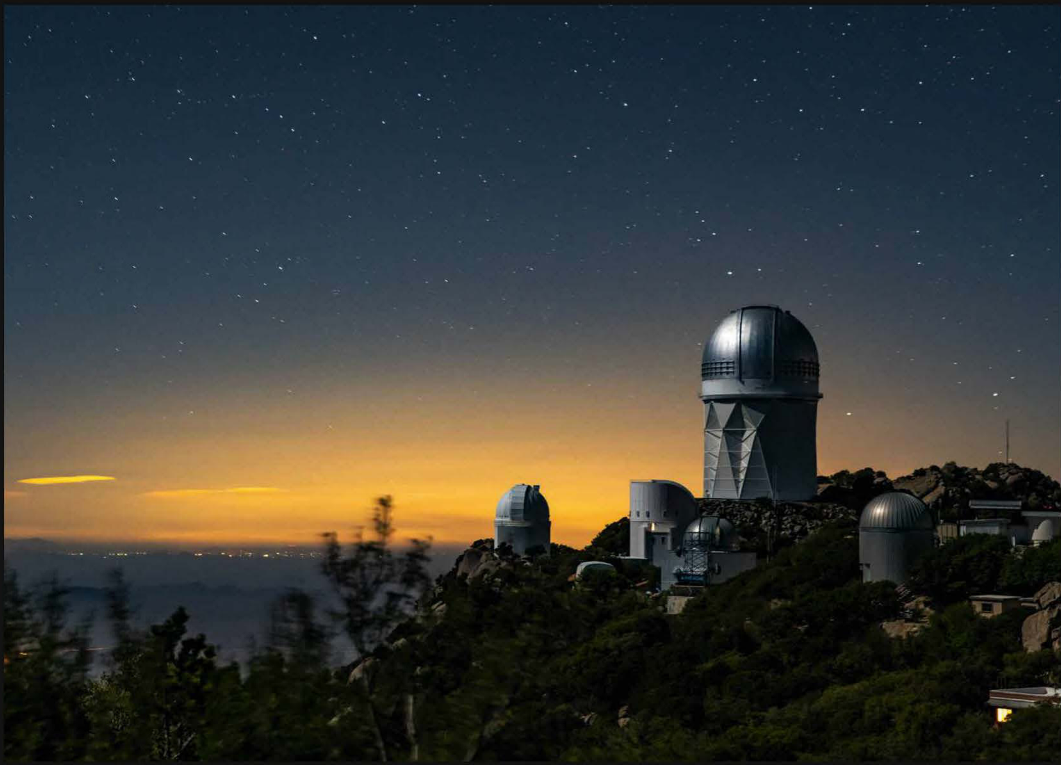
"The whole point of my work is to incorporate a more complex description of gravity into cosmological modeling, which we typically don't do," she says. Now, with more data about the Universe than ever before and increasingly powerful supercomputers to run simulations on, "We're getting the freedom to be able to remove some of those assumptions and see if we can build a better model."

Often, when cosmologists see the problems with the Standard Model, their first instinct is to try to introduce something – a new kind of energy, a new constant, a simplification – to fix the model.

But Macpherson's approach is different: "It's much rarer in the scope of all cosmologists to say, 'Hey, we've built this model based on simplifying approximations. Maybe all this weird stuff is just a consequence of those specific approximations breaking down'."

Though the simulation work is still very much in progress, so far the results are leaning toward the effects of the assumptions about gravity being very small and negligible.

Despite this, Macpherson says that, "As with any kind of science, or especially in this kind of numerical modelling, there are a billion caveats to that statement. There's still a lot of work to be done to be able to say for sure whether the assumptions matter or not."



"THERE'S A LOT OF REASONS TO THINK THAT THERE'S DEEPER PHYSICS BEHIND DARK ENERGY"

THE CHANGING CONSTANT

Even those who stand by the Standard Model of Cosmology will happily admit that dark energy is strange. Dark matter is puzzling enough, with its lack of interaction with light, but we can still detect it through its gravitational effects and think of it as, presumably, analogous to some extent with ordinary matter.

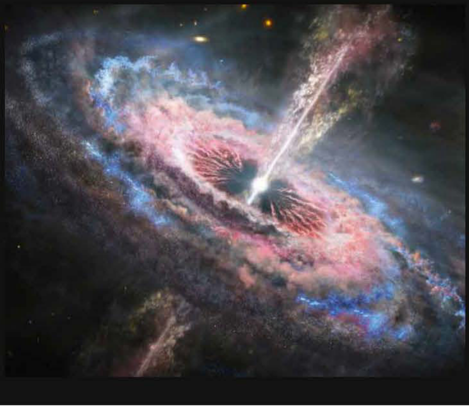
Dark energy is harder to conceptualise. The most prominent theories are that it's a property of space itself: that there's something about the existence of empty spaces that pushes outwards. Or, as cosmologists generally put it, that it has negative pressure.

But there are so many questions here. Why does space have this particular energy density, rather than any other amount? How do we relate this to quantum mechanics, which predicts that an empty vacuum should have an energy density that's orders of magnitude larger than what we actually see?

Though most cosmologists agree that dark energy is a useful term to describe a force that must be there due to the expansion of the Universe, what this

ABOVE The Dark Energy Spectroscopic Instrument on the Mayall Telescope in Arizona measures the effect of dark energy on the expansion of the Universe

RIGHT The distribution of quasars throughout the Universe also doesn't tally with our current understanding of the Universe's expansion



force actually *is,* is far harder to explain. “There’s a lot of reasons to think that there’s deeper physics behind dark energy,” Muir says.

Recent findings from observations carried out by the Dark Energy Spectroscopic Instrument and the Dark Energy Survey, on which Muir works, also support a long-held theory that dark energy could be changing over time. The idea is not just that as the Universe expands, there’s more empty space and this bigger space therefore means more dark energy. It’s that the density of dark energy *itself* is changing over time.

In this case, dark energy can’t just be represented by a cosmological constant, Lambda, because it isn’t constant – there are times in the Universe when it’s had a lower value, and there could be times in the future when it has a higher value. That’s hard to fit within the current Standard Model.

“It’s difficult to change the cosmological constant mildly, because there isn’t really a theory behind it,” says Dr Valeria Pettorino, a dark energy theorist at the European Space Agency. “It’s a constant. It’s there. It’s a bit added by hand.”

The idea of assuming dark energy to be a constant has been useful for research thus far. But how well that constant fits at different scales, and in different scenarios, is something that’s very much up for debate right now.

“The problem is, what happens if we are at very large scales?” Pettorino says. “What happens in the future, or in the past? Was it always like that? Will it always be like this?”

This leads into an even more intriguing concept: perhaps dark energy isn’t just one thing. It could be a whole family of forces that work together in complex ways to affect the Universe’s expansion.

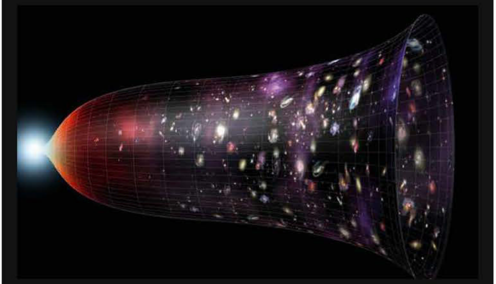
“The Universe that we know, the five per cent, it’s full of different particles, different forces,” says Pettorino. “So, imagine this 70 per cent of dark energy. It’s probably a combination of different things. I would be surprised to see this 70 per cent just made of one thing.”

CRACKS IN THE FACADE

We’re getting closer than ever to understanding dark energy, thanks to both ground-based surveys and the recently launched Euclid space telescope. Euclid is the most ambitious mission yet for understanding dark matter and dark energy, and it intends to create a map of the large-scale structure of the Universe in great detail.

ABOVE The European Space Agency’s Euclid mission ready to launch in July 2023

BELOW The Universe has been expanding ever since the Big Bang 13.8 billion years ago (left). Dark energy is assumed to be the reason why the expansion appears to be accelerating



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“In practice, the way we approach this is, we try and test the predictions of this minimal model with greater and greater precision,” says Muir. “The hope is, if you find cracks in that facade where the simplest model predictions don’t match observations, that could be a clue for where you need to go beyond that simplest description.”

To build up a map with the kind of high-level accuracy required to test these models, the Euclid telescope needs to have extremely precise instruments, like its 600-megapixel camera. Euclid will be able to assess the expansion rate of the Universe using two methods: observing both supernova explosions (which give out a predictable pattern of light) and leftover patterns in the distribution of galaxies from the earliest stages of the Universe, called baryon acoustic oscillations.

By having these two methods, the hope is that measurements of the expansion rate can be more certain. The resulting data can hopefully show which of the many models of dark energy are the best fit.

“The Euclid mission can test the Friedmann equation [the basis of the Standard Model of Cosmology], and it can test my model. So, if I’m wrong, then I can retire in five years,” Wiltshire says with a smile.

Whatever the results from Euclid are, they’re set to revolutionise cosmology.“We don’t necessarily think lambda is the full story. And so, we want to look for deviations from it that could tell us more,” Muir says. A more complex understanding of gravity, for example, could change the way that we think about dark energy. But Muir also cautions: “Extraordinary claims require extraordinary evidence.” **SF**

by **GEORGINA TORBET**

Georgina is a freelance science and technology writer who specialises in space exploration and cosmology. She also has a PhD in psychology.

THE BIG QUESTION

How can I reduce my cholesterol without statins?

You don't need medication to improve cholesterol levels. A few simple dietary tweaks can make a serious difference

by HATTY WILLMOTH

High cholesterol is, unfortunately, very common. The British charity Heart UK estimates that nearly half of all adults in England have above-average cholesterol levels, while the US Centers for Disease Control and Prevention estimate that 1 in 10 Americans – that's 34 million people – have cholesterol levels exceeding the high-mark of 240mg/dL (milligrams per decilitre).

These people are all at high risk for heart attacks and might not even know it. High cholesterol doesn't come with any obvious symptoms and, unless a person has recently had their blood tested or experienced a medical issue, it's likely that the cholesterol in their blood is a mystery to them.

If you're worried about your levels, it's a good idea to have a chat with your doctor. If there's cause for concern, they may recommend a cholesterol-lowering medication, such as a statin. There's a good chance that you know somebody who takes one: 8 million people take a statin daily in the UK, with the number being closer to 40 million in the US.

> **"Cholesterol is not inherently bad. We need it to survive"**

Here's an easy pill to swallow, however: you don't *need* statins. Unless your levels are very high or there's a specific medical reason to take them, there are plenty of ways you can lower your cholesterol level naturally.

The first, you won't be surprised to hear, is exercise. A 2013 paper reported that aerobic activities, such as running or cycling, can lower 'bad' cholesterol and raise 'good' cholesterol, both by approximately five per cent.

Quitting smoking is also advisable. It's well known that cigarette smoke increases 'bad' cholesterol and raises the risks to our health, but a 2019 paper suggested that vaping might also have a similar effect.

Yet the very best thing to improve cholesterol levels is to change our diets, that's according to NHS doctor and University College London academic cardiologist, Dr Riyaz Patel. You can probably guess some of the big food no-nos, with an ever-growing pile of research pointing the finger at the usual suspects of pastries, processed meats and lard. Best to leave those out of the

ALAMY

Oats are a good source of soluble fibre. Consuming 5–10g (about 0.5oz) or more of soluble fibre a day can decrease your levels of LDL 'bad' cholesterol

shopping trolley for the good of healthier cholesterol levels. Other suggested food swaps, however, might surprise you.

THE GOOD AND BAD OF CHOLESTEROL

Before delving deeper into the possible changes to our eating habits, it should be clarified that cholesterol is not inherently bad. We need it to survive.

The waxy substance is found throughout the body and is a key component of cell membranes, helping to produce hormones such as testosterone and oestrogen. It also plays an important role in the body's vitamin D and bile acids, which break down foods.

The problem lies in when we have too much of a specific type of cholesterol called low-density lipoprotein (LDL), the 'bad' cholesterol.

"It's important to understand which part of your cholesterol is high," says Patel. "Fat-like cholesterol can't float freely in the blood. It needs to be packaged in particles called cholesterol lipoproteins."

We can think of these lipoproteins as tiny delivery vans that cart cholesterol around the body, with LDL delivering from the liver to the bloodstream and high-density lipoprotein (HDL) – the 'good' cholesterol – delivering from the bloodstream to the liver.

LDL cholesterol is a pretty bad driver, though: while zipping about in the bloodstream, it has a habit of crashing into the lining of our arteries, the endothelium.

That shouldn't be a problem for healthy arteries, but if they've been damaged – from high blood pressure, smoking, pollution, ageing, inflammation or a number of other factors – then the LDL can get trapped inside.

When that happens, plaque then builds on top of it. "Heart attacks happen when a bit of plaque cracks and causes a clot on top and blocks an artery," says Patel. "So, having plaque is a problem."

THE FOODS TO ADD TO YOUR DIET

Now that we know the basics of cholesterol (and why we should never get into a car when LDL cholesterol is behind the wheel), which foods can help keep it at healthy levels?

"Oats are a really good way of naturally reducing cholesterol," Patel says. "It's to do with the fibre. The oats contain soluble fibre that lowers cholesterol."

Soluble fibre – also found in wholegrains, lentils, beans, vegetables, fruit, nuts and seeds – can bind to dietary cholesterol in the small intestine, which then prevents the cholesterol from entering the bloodstream.

"The other thing is sterols and stanols," adds Patel. These are plant-based compounds – found in fortified yoghurts and spreads, or supplements – that our bodies confuse with cholesterol.

When we eat food containing cholesterol, receptors in the gut identify it to be absorbed into the bloodstream. Sterols and stanols can trick those receptors and get absorbed instead. The result is that more cholesterol will be removed through bodily excretions and less of it ends up in our bloodstream.

"They are probably the best non-pharmaceutical way of lowering your cholesterol, typically by about 10 per cent or so," says Patel. "They're quite effective."

WHAT TO CUT OUT

That's the good stuff that we can be putting into our bodies. What about the 'bad' foods that increase cholesterol? Should they be taken out of our diets?

There used to be a time when the humble egg yolk could strike fear into the hearts of cholesterol-phobes. And while it's true that eggs contain quite a lot of dietary cholesterol, there's no need to panic over a couple of poachies on toast.

"Dietary cholesterol doesn't equal circulating cholesterol. That's very clear," says Patel. "In the old days, we used to say that foods high in cholesterol are bad for you because they increase it. That's not true."

In fact, around 80 per cent of the cholesterol circulating around the body is made by the liver; not absorbed directly from food.

That's not to say, though, that food doesn't impact our LDL cholesterol indirectly. For instance, it can interfere with the liver's ability to regulate cholesterol levels in the blood.

Similar to statins, certain foods act like a drug that changes how the liver works. Take saturated fat, for instance. Found in fatty or processed meat, butter, cheese, pastries, deep-fried food and coconut oil, eating more saturated fat is associated with having more LDL cholesterol in your bloodstream.

"Let's say you're having lots and lots of pastries with a lot of saturated fats in them," says Patel. "As those saturated fats get absorbed, they interfere with the liver's ability to get rid of LDL cholesterol, so the LDL levels build up." Sugar can also impact cholesterol levels by encouraging the liver to produce more LDL and less HDL.

Do we therefore have to swear off pastries and sugar for good and eat nothing but oats for every meal? Well, no. Swinging too far in any direction can have adverse and unpredictable effects on your health. The answer, according to Patel, is to have a healthy, well-rounded and balanced diet.

"When it comes to advising my patients, I recommend eating a mixed, balanced diet – one that's not too heavy in carbs, not too heavy in saturated fats – and to minimise ultra-processed foods as much as you possibly can."

Ultra-processed foods, along with the saturated fats and sugar, might lead to inflammatory damage to the arteries. They can also increase the risk of developing metabolic conditions, such as type 2 diabetes, which in turn makes heart disease more likely.

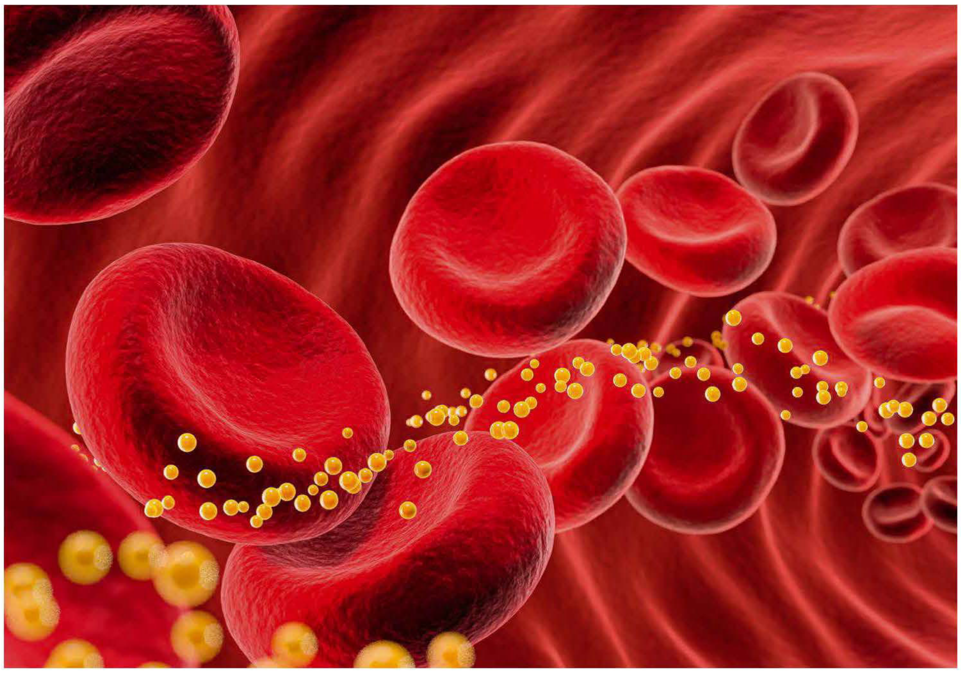
"Just eating everything in moderation is probably the optimal position to be in," Patel concludes.

"A balanced diet is driven partly by what you want to eat when you're hungry. Your body is quite good at knowing what it needs." **SF**

> **"A balanced diet is driven partly by what you want to eat when you're hungry. Your body is quite good at knowing what it needs"**

by **HATTY WILLMOTH**

Hatty is a trends editor at BBC Science Focus. *Her areas of interest include food, nutrition and health.*



Fat-like cholesterol (in yellow) is packaged in lipoproteins in order to be transported within the bloodstream

GETTY IMAGES

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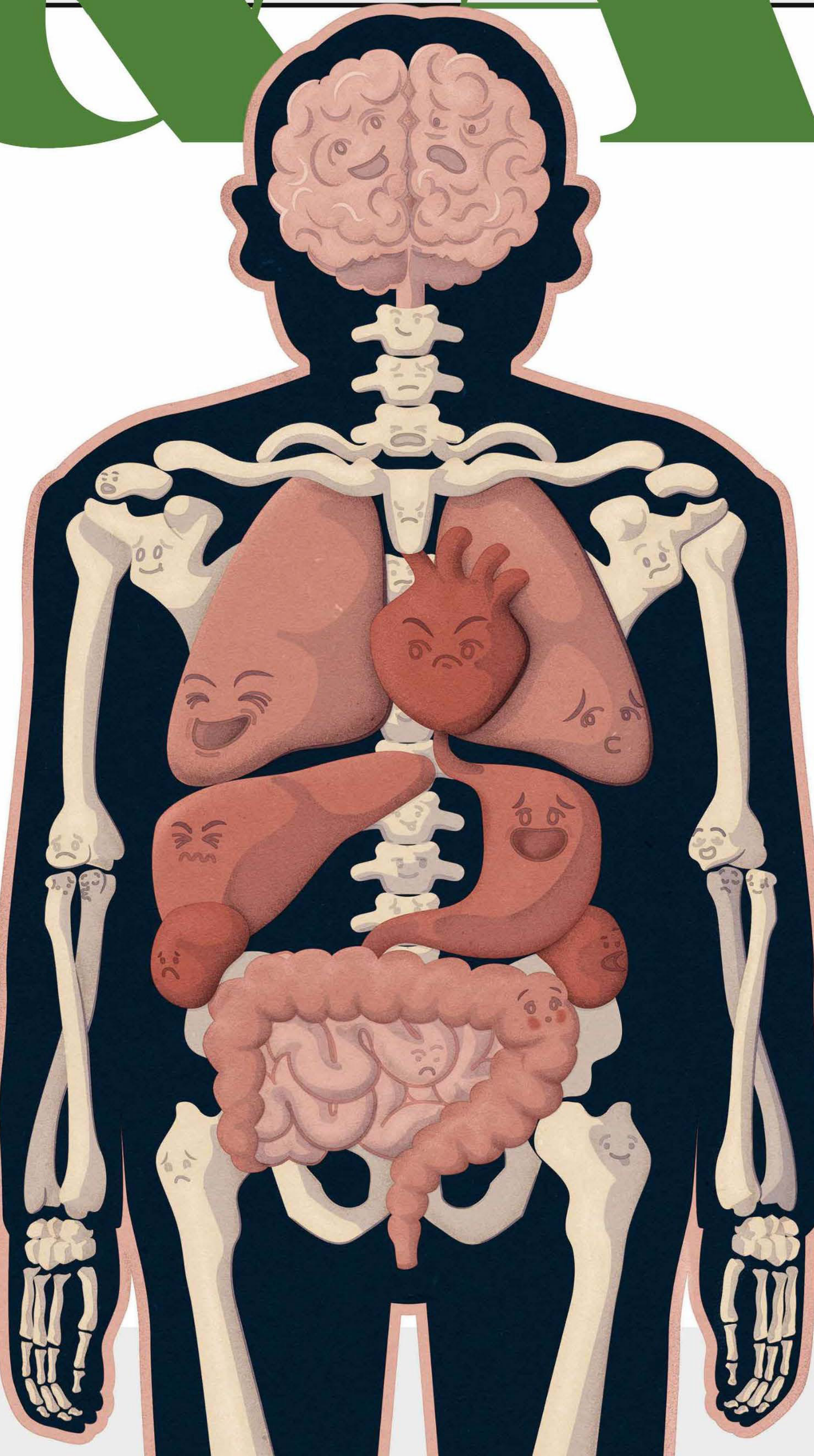
Q&A

YOUR QUESTIONS ANSWERED



ELISE VAUGHN, SHEFFIELD

WHY DO WE FEEL EMOTIONS IN DIFFERENT PARTS OF OUR BODIES?

Whether it's a hot flash of anger, butterflies in the stomach or a light-headed rush of joy, we often experience emotions as physical sensations.

This is all due to the interplay between our mental and physical experiences. If we're feeling anxious during a first date, for example, the fight-or-flight response can kick in, releasing hormones (including adrenaline) that increase heart rate and tense muscles. This can be felt in the body as a tight chest or shakiness.

Both positive and negative emotions can trigger changes in breathing, sweating, skin sensitivity, salivation, blood flow, body temperature, facial tension and even the digestive system. It's no coincidence that we talk about 'gut feelings' and 'gut-wrenching anxiety'. These physiological changes can often affect our emotions – a constant feedback loop between the body and the mind.

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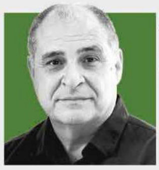
Astrophysics

CERI PERKINS
Environmental science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Everyday science

> “ALTHOUGH WE ALL FEEL OUR EMOTIONS SLIGHTLY DIFFERENTLY, IT TURNS OUT THERE ARE LOTS OF SIMILARITIES”

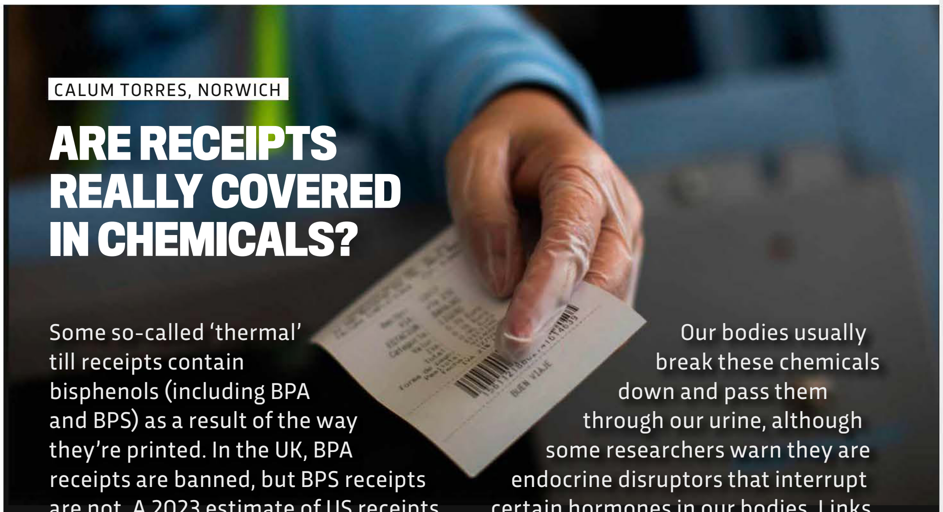
In 2013, researchers in Finland created ‘body maps’ of emotions by asking people to match their body parts to different emotional experiences. Although we all experience our emotions slightly differently, it turns out there are lots of similarities in where we feel them. Anger, for example, is often experienced in the chest and hands, while happiness is felt strongly in the chest and face.

However, the way we think about emotions in the body may have changed over time. A follow-up study in 2024 mapped the emotions of people living around 3,000 years ago in Mesopotamia (within modern-day Iraq), analysing one million words from ancient texts to find links between emotional expressions and references to body parts.

The researchers found some similarities with present-day humans. Pride, for instance, was linked by Mesopotamians to the heart, as it often is today. But intriguingly, happiness was most associated with the liver, and anger was linked to the legs.

These differences may be due to Mesopotamian cultural beliefs about the body. The liver was thought to be the central organ of the body and location of the soul, which could explain why it was associated with joyous feelings. ***JL***

ALAMY X2 ILLUSTRATION: DANIEL BRIGHT



CALUM TORRES, NORWICH

ARE RECEIPTS REALLY COVERED IN CHEMICALS?

Some so-called ‘thermal’ till receipts contain bisphenols (including BPA and BPS) as a result of the way they’re printed. In the UK, BPA receipts are banned, but BPS receipts are not. A 2023 estimate of US receipts suggested that 80 per cent contain BPAs. Is that a problem? BPAs are commonly found in a range of consumer products, including plastic water bottles and canned food.

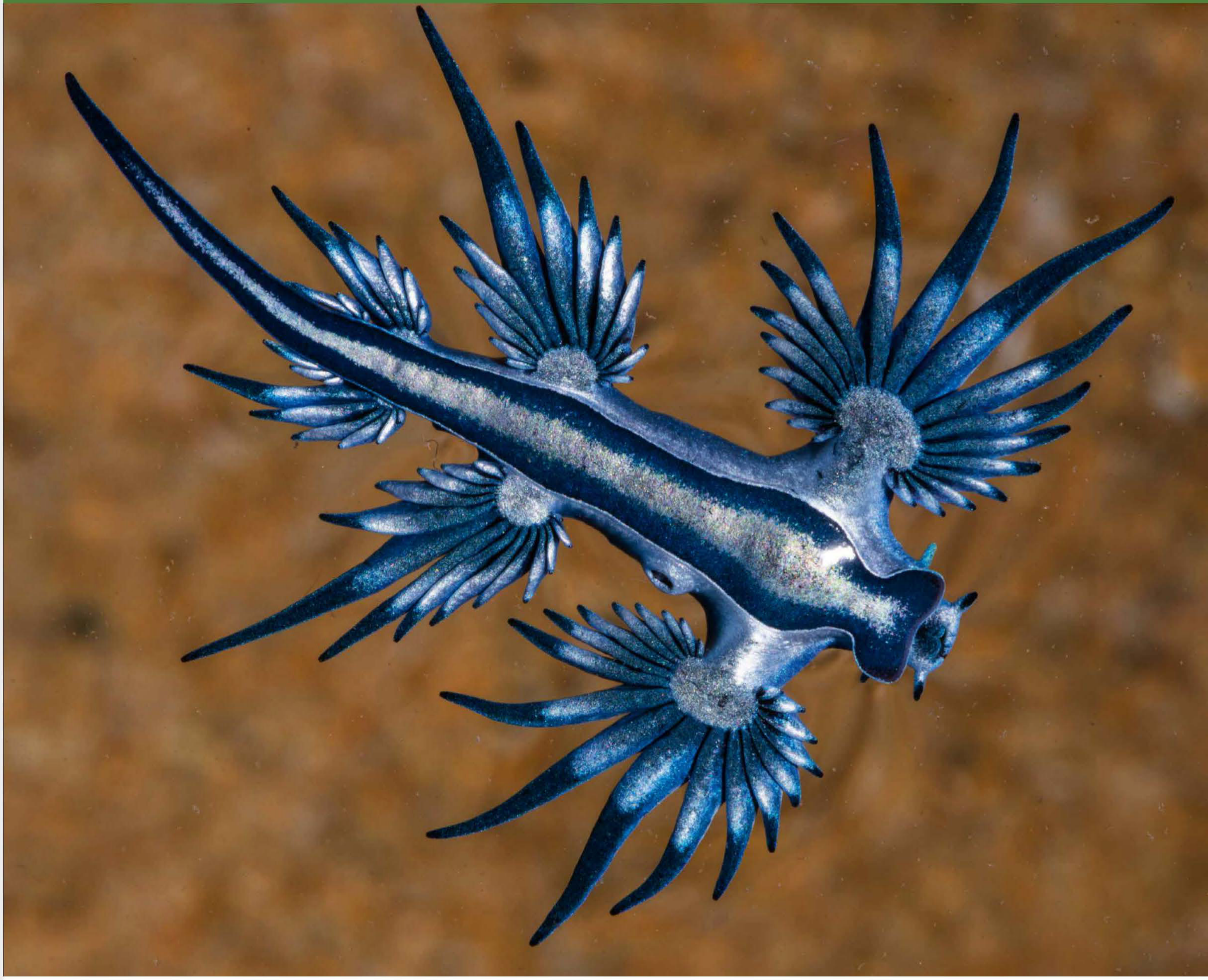
Our bodies usually break these chemicals down and pass them through our urine, although some researchers warn they are endocrine disruptors that interrupt certain hormones in our bodies. Links have also been made between BPAs and cancer, but Cancer Research UK says there’s insufficient evidence for this. If in doubt, just leave the receipt. It’ll only end up in the bin anyway. ***IT***

SIMONE FAULKNER, VIA EMAIL

WHAT DO MUMMIES SMELL LIKE?

Woody, spicy and sweet. That’s how the smells of mummified bodies were described in a recent study at the Egyptian Museum in Cairo – not bad considering they are around 3,000 years old.

A combination of human ‘sniffers’ and scientific instruments revealed that the heady smells weren’t just from the oils, balms and resins used to preserve the bodies. The musk also came from the museum’s conservation products, and microbial activity on the mummies as they deteriorate. The researchers plan to recreate the aroma for museum visitors, and say that their work could provide a non-invasive way to monitor a mummy’s condition. ***JL***



THE BLUE DRAGON

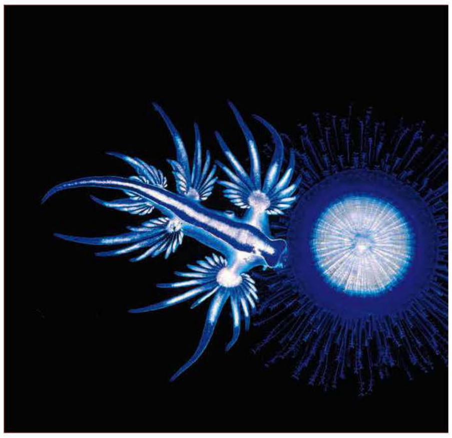
Far from the shore, out in the vast expanses of the open seas lives a group of unusual animals, collectively known as 'neuston'. Their home is the giant, two-dimensional skin of the sea, which forms a link between the atmosphere and the ocean. Within this family, one of the most curious creatures is a type of sea slug, or nudibranch, more commonly known as blue dragons, sea swallows or blue glaucus, thanks to their scientific name *Glaucus atlanticus*.

Blue dragons spend their lives hanging down from the surface, buoyed by a bubble of air that they swallow. To keep hidden from predators, they use a two-sided biological trick known as countershading. Hanging upside-down, the underside of their body is vivid blue, blending into the ocean below and hiding from winged predators above. Their other side, the side that hangs down from the surface, has silvery stripes like the shimmering surface of the sea, helping them disappear from swimming predators looking up.

Overall, blue dragons are odd-looking for sea slugs. The main part of their 3cm (0.4in)-long body is sluggy enough, but poking out sideways are three pairs of splayed appendages that look like long fingers of different lengths.

These are not for waving or swimming. They're a part of the sea slug anatomy known as cerata, which essentially act as second gills, extending the gut and respiratory system outside of their bodies to help them breathe.

Blue dragons, like many sea slug species, also use their cerata as weapons. They're vicious hunters, with their main prey being other blue-tinted members of the neuston,



> “THEY’RE VICIOUS HUNTERS, WITH THEIR MAIN PREY BEING OTHER MEMBERS OF THE NEUSTON”

including Portuguese man-o-wars (*Physalia physalis*) and jellyfish-like stinging creatures such as blue buttons (*Porpita porpita*) and by-the-wind sailors (*Velella velella*).

Blue dragons can bite off chunks of these creatures without getting stung. Remarkably, the sea slugs can then repurpose their prey’s stingers, keeping them intact and pushing them to the surface of their cerata. Then, when they’re threatened by predators, they can launch the stingers at them as a dangerous deterrent.

A modern threat puts the blue dragons and other members of the neuston family at risk. Surveys between Hawaii and California have shown that they occupy the same remote parts of the Pacific Ocean as the notorious Pacific Garbage Patch, where floating plastic debris is swept together by a swirling oceanic current. One method of dealing with this plastic pollution is to sling a net between two ships to skim debris from the sea surface. This process could also be catching large numbers of neustons, however.

The full ecological impact of this process is not yet fully understood, but it could have wider implications for the oceanic food web – these animals are an important food source for many other marine species, including sea turtles and seabirds. ***HS***

MATTY SMITH PHOTO, GARY BELL/OCEANWIDE/MINDEN/NATUREPL.COM, SCIENCE PHOTO LIBRARY

HENRY BECKER, DURHAM

HOW DOES BACKGROUND RADIATION AFFECT PARTICLE DETECTORS?

On 16 July 1945, the world changed forever when Manhattan Project scientists detonated the world’s first atomic bomb. The Trinity Test left a radioactive legacy, as did the subsequent decades of above-ground nuclear testing (528 detonations in total) that filled the atmosphere with radioactive particles.

The air we breathe is now slightly more radioactive. This has had unexpected consequences for some of the materials we produce. Steel, for instance, is made by forcing purified oxygen through molten iron ore. But because today’s air is subtly radioactive, so is the steel we produce.

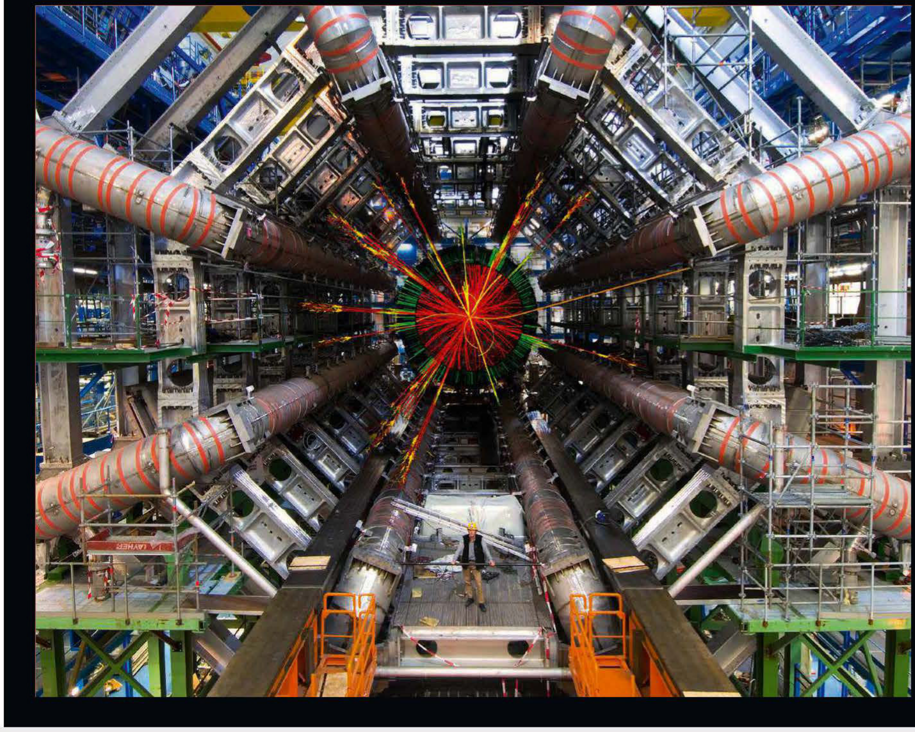
Fallout from weapons testing peaked in 1963, and levels have since dropped by more than 95 per cent as the radioactive particles in the atmosphere have gradually decayed. The steel we make today isn’t a health threat, but its faint radioactivity can still interfere with sensitive scientific equipment, such as instruments built to detect dark matter.

Scientists now have to seek out material with minimal radiation contamination. Steel produced before the first nuclear detonations in 1945 contains significantly fewer radioactive particles, making it valuable in particle physics research. Most of this ‘low-background steel’ is salvaged from shipwrecks, such as the fleet of 52 German battleships abandoned in the shallow waters of Orkney, Scotland.

The demand for low-background steel has sparked controversy, however. In 2017, news broke that up to 40 WWII-era warships had been illegally plundered by salvage divers around Singapore, Indonesia and Malaysia. The discovery caused outcry among veterans and historians, who respect the wreckages as underwater war graves.

Ancient Roman lead is also prized among physicists for shielding ultra-sensitive experiments from background radiation. Lead ore is naturally radioactive. Once it’s been processed, it still contains trace amounts of the isotope lead-210, which has a half-life of 22 years. While it would take centuries for freshly-mined lead to become suitable for use in particle physics, lead mined by the Romans has had plenty of time to lose its radiation.

In 2010, Italy’s National Archaeological Museum honoured a long-standing agreement, handing over 120 lead ingots – recovered from a Roman ship that sank around 80-50 BC – to the National Institute of Nuclear Physics to be melted down and used to shield an upcoming experiment. ***CP***



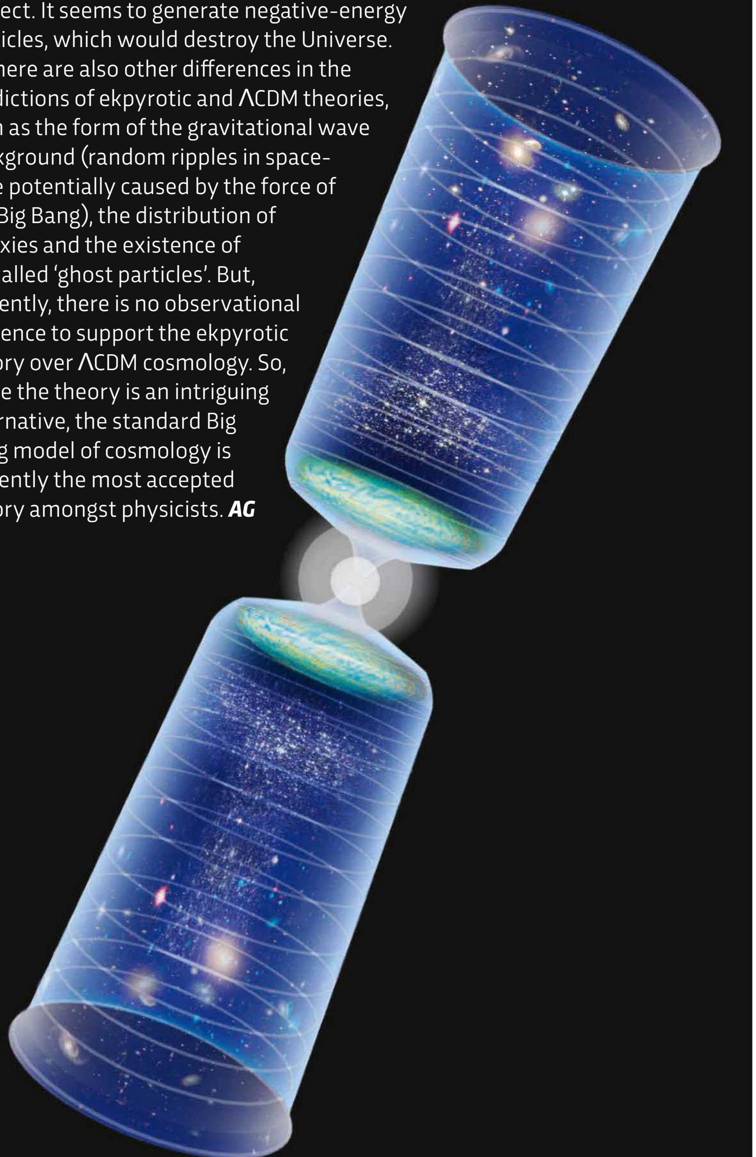
LUIS DOYLE, VIA EMAIL

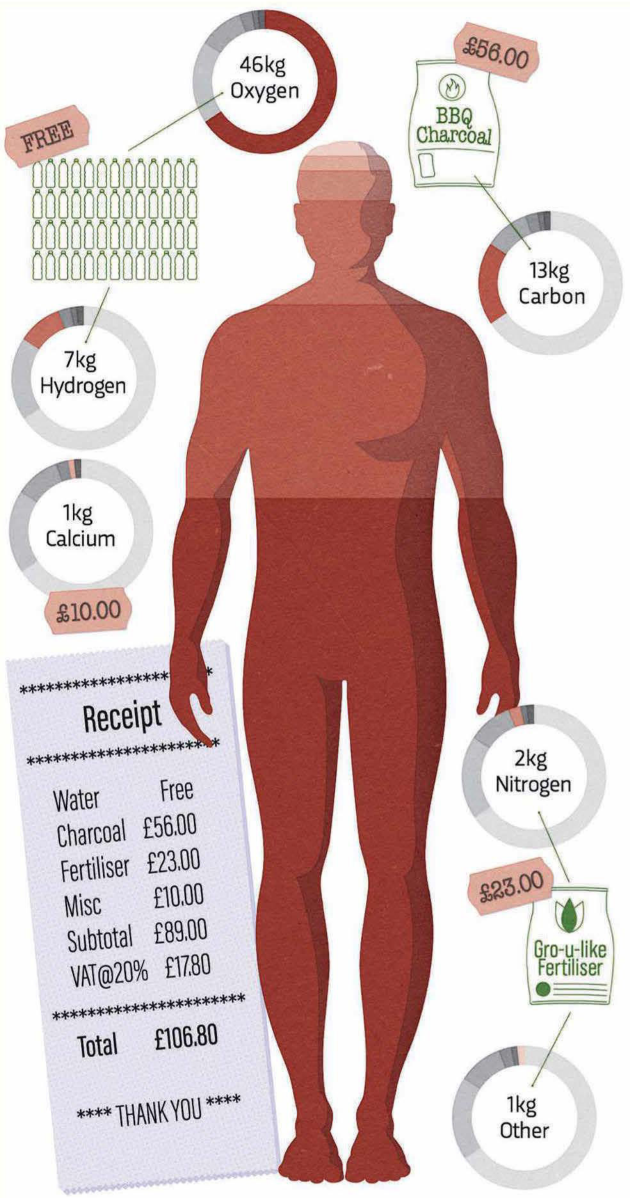
WHAT IS THE EKPYROTIC UNIVERSE THEORY?

Ekpyrotic cosmology is an alternative theory to the standard theory of cosmology, which is known as the Lambda-CDM, or ΛCDM model. In the ΛCDM model, the remarkable flatness of the Universe requires a period of rapid 'inflation', which smooths out the early variations in density and temperature. Although there is no direct proof of this inflation, or a likely cause, it neatly explains many complicated aspects of the Universe we see today, and is perfectly consistent with current observations.

In ekpyrotic theory, however, there is no beginning of time, and the Big Bang is replaced with a 'bounce' between two 'branes' – three-dimensional worlds in a five-dimensional space-time. The structure of the current Universe is determined before this bounce, so the need for inflation is avoided. The theory also avoids the inconvenient 'singularity' built in standard Big Bang cosmology. But the theory isn't perfect. It seems to generate negative-energy particles, which would destroy the Universe.

There are also other differences in the predictions of ekpyrotic and ΛCDM theories, such as the form of the gravitational wave background (random ripples in space-time potentially caused by the force of the Big Bang), the distribution of galaxies and the existence of so-called 'ghost particles'. But, currently, there is no observational evidence to support the ekpyrotic theory over ΛCDM cosmology. So, while the theory is an intriguing alternative, the standard Big Bang model of cosmology is currently the most accepted theory amongst physicists. ***AG***

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FREE
13kg
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7kg
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Calcium
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Charcoal £56.00
Fertiliser £23.00
Misc £10.00
Subtotal £89.00
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2kg
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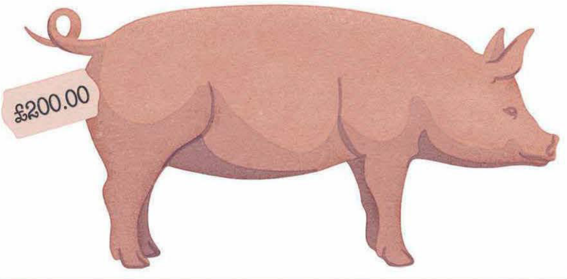

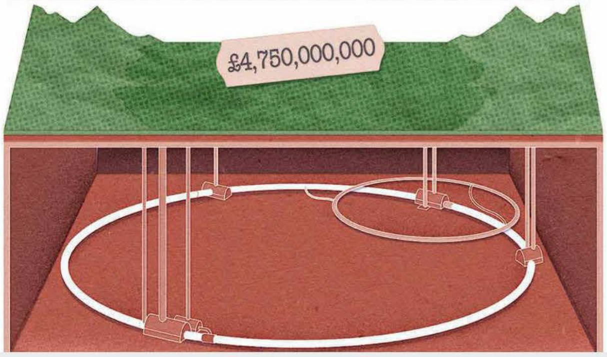
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PHOEBE GRAY, SOUTHAMPTON

HOW MUCH DOES THE AVERAGE HUMAN BODY COST?

If we consider the individual elements, a typical 70kg adult body consists of about 46kg (101lbs) of oxygen, 13kg (27lbs) carbon, 7kg (15lbs) hydrogen, 2kg (4lbs) nitrogen and a kilo (2lbs) of calcium, plus another kilo (2lbs) combined of phosphorus, sulfur, potassium, sodium, chlorine, magnesium and some trace elements.

In his book *The Body: A Guide for Occupants*, author Bill Bryson calculates the total cost of these raw materials as over £116,000 ($150,000), but he was using the most expensive, chemically pure form of each element. If you're prepared to do the refining yourself, a body would end up costing a lot less. For example, using 52 litres (11 gallons) of water, which is essentially free, can get you the oxygen and more than enough hydrogen. With a simple electrolysis setup, you could easily then separate this into the required gases.

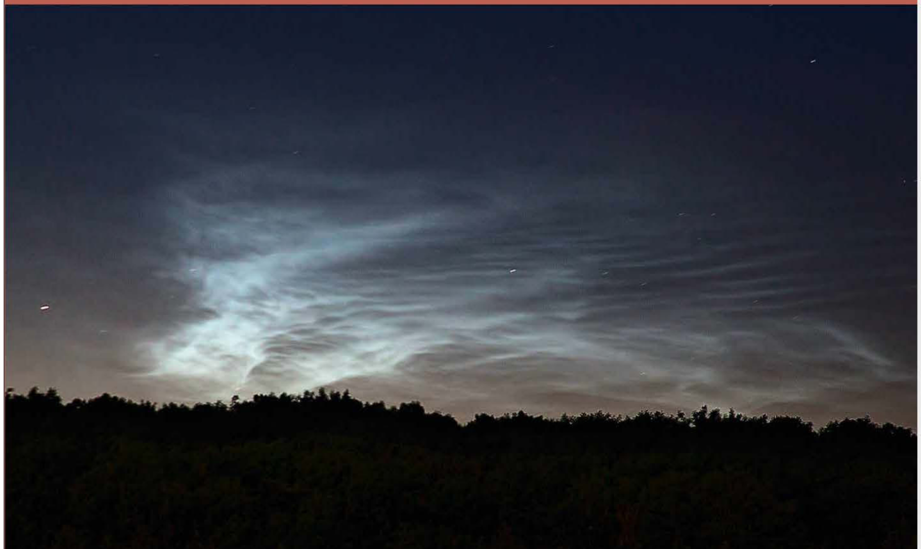
Similarly, you could get the carbon from good quality charcoal (which is about 70 per cent carbon), for £56 ($75) at the shops. Add 10kg (22lbs) of ammonium sulphate fertiliser to your shopping trolley for £23 ($31) to create the nitrogen and sulphur, and you're basically there. All the other elements mostly appear in such small quantities that they'd only add another £10-15 ($13–20) of value, bringing the revised cost estimate to under £100, or $133.

Of course, humans aren't actually made of elements – they're made of complex organic molecules, such as proteins and carbohydrates. The cost of synthesising these from raw elements would dwarf the price of the materials themselves. If you're not squeamish, a much easier option would be to buy a whole pig (around £200 or $267 at auction) and grind it up into a soup of useful chemical building blocks. From a molecular standpoint, a pig and a human are essentially the same thing.

Alternatively, you could start with pure energy. Matter and energy are interchangeable, so in theory, we could use a particle accelerator like the Large Hadron Collider to create atoms from pure energy. To make 70kg (154lbs) of stuff, however, you would need to start with about 10^{17} joules of energy. This is equivalent to 1.75 trillion kilowatt hours of electricity – about 70 times as much as the entire world uses in a year. ***LV***

ALAMY ILLUSTRATIONS: DANIEL BRIGHT, PETE LAWRENCE

ASTRONOMY FOR BEGINNERS



IF PRESENT, NOCTILUCENT CLOUDS ARE TYPICALLY SEEN LOW ABOVE THE NORTHWEST HORIZON 90–120 MINUTES AFTER SUNSET, OR A SIMILAR TIME BEFORE SUNRISE, LOW ABOVE THE NORTHEAST HORIZON.

THEY OFTEN SHOW FINE MESH-LIKE STRUCTURES OR HERRINGBONE PATTERNS AND HAVE A DISTINCTIVE SILVERY-BLUE COLOUR.

A LOW, FLAT HORIZON IN THE VIEWING DIRECTION IS RECOMMENDED.

HOW TO SEE NOCTILUCENT CLOUDS

WHEN: SUMMER

The summer months are difficult times for stargazing. The length of day is at its greatest on 21 June, the summer solstice, when Earth reaches a point in its orbit where its northern pole is the most tilted towards the Sun. In this position, from the northern hemisphere, the Sun climbs to its highest altitude above the southern horizon around the middle of the day, but also only sinks to a minimum altitude below the northern horizon in the middle of the night. This creates a situation where twilight technically lasts all night, making stargazing a challenge.

During the UK's summer months, however, noctilucent clouds (NLCs) fill the void left by the perpetual twilight. NLCs are high-altitude ice-sheet clouds and, although it might sound odd to get excited over clouds when talking about astronomy, they have a link to space. The tiny ice crystals – which appear around 82km (around 51 miles) up in the mesosphere – form around the dust produced by meteors. The resulting thin ice sheet is so high that it's still able to reflect sunlight, even though it's twilight (or dark) on the ground. Shining against the deep twilight, this is where their name comes from, noctilucent meaning 'night-shining'.

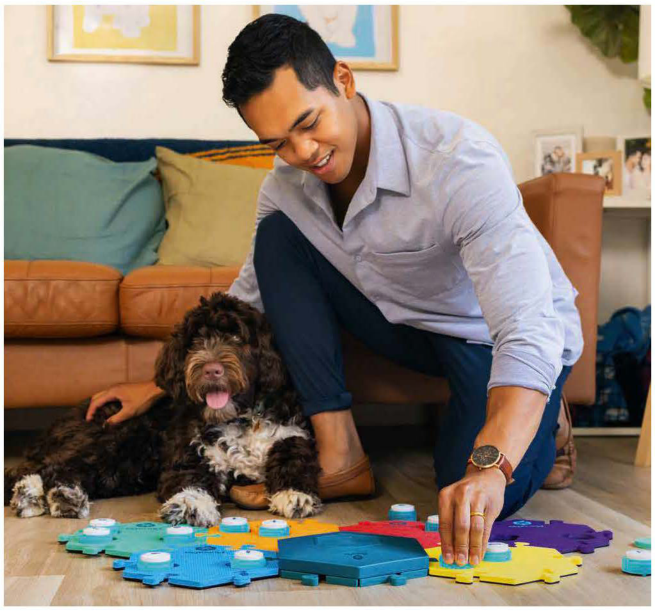
There's no guarantee that NLCs will be visible – the only way to know is to keep checking. Typically, NLCs can be seen 90 to 120 minutes after sunset, low above the northwest horizon and at a similar time, low above the northeast horizon before sunrise. Big displays can be seen starting low above the northwest horizon, tracking north and ending above the northeast horizon around dawn. Over the years, NLC spotting has become a popular summer pastime and last year there were some excellent displays. What will 2025 hold in store? There's only one way to find out.

by **PETE LAWRENCE**

(@Avertedvision)

Pete is an astronomy expert and presenter on The Sky at Night.

WATCH *THE SKY AT NIGHT* ON BBC FOUR AND BBC IPLAYER



HATTIE KINGSTON, BRISTOL

DO DOGS REALLY UNDERSTAND THE WORDS USED ON SOUNDBOARD BUTTONS?

Scour the internet and you'll find many adorable videos of dogs who have seemingly learned to 'talk' to their owners, by pressing electronic buttons, preprogrammed to say certain words. There's Copper the labrador, who pushes the 'Copper' and 'eat' buttons when she wants cheese, and Bunny the poodle crossbreed, who will tap out 'where' and 'Dad' when her owner is away. It looks impressive, but are these dogs really communicating, or are they just responding to cues from their owners?

Intrigued, Federico Rossano from the Department of Cognitive Science at UC San Diego enlisted the help of 59 dogs who had all been trained by their owners to use these soundboards. Working in their homes, owners and researchers randomly pressed certain buttons and then recorded whether or not the dogs responded appropriately. Were they more likely, for example, to head to the door after hearing the word 'outside' versus looking at their food bowl or having a scratch.

The answer, for certain words at least, was 'yes'. Dogs were more likely to show play-related behaviours in response to the word 'play' and look to the door when they heard 'outside'. Critically, these responses held true, regardless of whether it was their owner or a researcher who pressed the button, and also whether their owner pressed the button or said the word themselves. This, says Rossano, is evidence that the dogs are not reading their owner's body language, and are instead really processing the words.

Case closed? Not so fast. While the study shows that dogs recognise and respond to verbal cues (which we already knew), critics argue that this doesn't tell us what the words mean to the dogs. So, when Bunny asks, 'Where Dad?' and her owner responds, "He's on a climbing trip right now," what is she really thinking? For now, only Bunny knows. ***HP***

DANI SHERMAN, VIA EMAIL

ARE NEGATIVE-CALORIE FOODS REAL?

Negative-calorie or zero-calorie foods are controversial despite their popularity on diet websites. The idea is that our bodies use as much (or more) energy to digest a chosen fruit or vegetable as the energy it provides.

But there's no scientific evidence for this food fad, with even the lowest calorie foods, such as celery and watercress, containing more energy than the body needs to process them.

In 2019, researchers from the University of Alabama ran a study on celery-munching bearded dragons. The choice of animal may seem unusual, but bearded dragons have an omnivorous diet and the same mechanisms for digesting food as humans.

The giant lizards ate five per cent of their body weight in celery. The researchers measured their metabolic rates, and collected faeces and urine to calculate the energy lost to excretion. They found that the lizards only used about three-quarters of the celery energy, debunking the idea of negative-calorie foods.

In any case, some nutrition experts argue that it's not sensible to focus on calories for maintaining or losing weight, because our bodies use different biological mechanisms to digest different types of food. We use far more energy to digest proteins than fats or carbohydrates, which have highly accessible energy. So, the calorie content is less important than the types of foods you're consuming.

Ultra-processed foods also tend to be high in fats and carbohydrates, offering instant satisfaction, but they also deliver a big dose of energy, much of which we store in fat cells. Whole foods, especially those packed with protein and fibre, generally require more energy to digest than processed foods.

Fresh fruit and vegetables touted as negative- or zero-calorie foods make a valuable contribution to a balanced diet. But if you tried to survive on these alone, you'd risk not only depriving yourself of nutrients, but also becoming very hungry and irritable. ***ED***

ALAMY X2, JUAN CARLOS MUNOZ/NATUREPL.COM ILLUSTRATION: DANIEL BRIGHT

THOMAS MCPHERSON, WAKEFIELD

HOW CAN I LOOK AFTER MY KNEES AS I GET OLDER?

Atrophy comes for pretty much every part of our bodies, but the effects of time are particularly rough on the knees. Why? Because they're complicated anatomical machines with a number of moving parts, all of which wear and tear with use.

As we age, the muscles that stabilise the knee weaken, and our bone density drops. The cartilage that cushions the bones wears thin. The ligaments that connect the bone and muscle also become less elastic. The upshot of all of this, for most of us: stiffness, pain, a reduction in mobility and an increase in the involuntary vowel sounds we make as we get off the sofa.

Like any machine, however, if they're well looked after, our knees respond in kind. That starts with an understanding of what increases your risk of knee injuries and osteoarthritis.

The natural enemies of good knees include excess body weight, footwear that offers no support and repetitive movements that ask a lot of your joints. For example, in 2021, French researchers found that parkour athletes sustained an average 1.7 knee or ankle injuries for every 1,000 hours they trained.

Not as bad as you might think, but it's the long-term damage that accumulates – and it's not only people who jump off buildings who are at risk. Research on elite dancers found that knee injuries, such as meniscal tears, are among the most common injuries.

Any movement that involves impact through the legs, or twists the rotation to change direction, is going to ask a lot of the knees. A dreaded ACL injury can keep a footballer off the pitch for up to a year. But research also suggests that 10 to 20 years after the injury, half of those injured will have osteoarthritis associated with the original damage.

There's also some debate about whether or not running is good for the knees or bad. It's said that road running, for example, is akin to hitting the soles of your feet with a hammer for an hour. But a 2017 study compared the risk of knee osteoarthritis in runners with non-runners and found no significant difference.

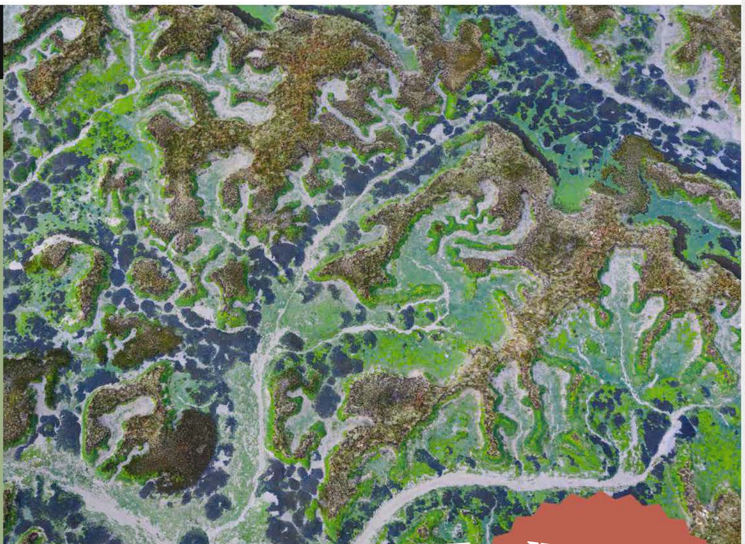
In fact, exercise is believed to strengthen your joints – even load-bearing movements. A 2023 study found that people who engaged in strength training are 20-per-cent less likely to suffer osteoarthritis than those who've never done it. Strengthening surrounding muscles, like the quadriceps, also seems to be beneficial.

Assuming you've bought some well-cushioned shoes and are exercising regularly, the other best-care practice with dodgy knees is to acknowledge any mild discomfort. Small injuries can develop quite easily into something more serious and long-term. If you do have pain, try wearing a knee support or going swimming. Some research suggests that, because it's non-weight bearing, swimming can aid recovery from minor knee injuries and reduce the risk of long-term issues. ***IT***

QUESTION OF THE MONTH

PETER RICHARDSON, TIVERTON

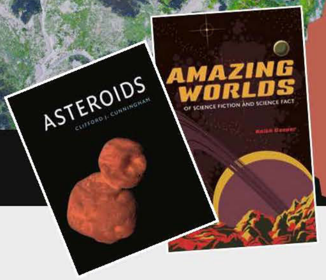
DO THE TIDES OF DIFFERENT SEAS AFFECT EACH OTHER?



The Moon's gravity causes all the seas and oceans in the world to bulge outwards on the sides facing directly toward and away from the Moon, with low points in between. Because Earth rotates and the Moon orbits Earth, the two bulges sweep around Earth every 24 hours and 50 minutes.

But local geography affects the tides a lot, too. In the English Channel, the tide sloshes in from both the Atlantic and the North Sea. The peaks reach Weymouth at slightly different times, so it regularly gets a low tide that comes back in slightly before going out again for a second time each day. ***LV***

EMAIL YOUR QUESTIONS TO **QUESTIONS@SCIENCEFOCUS.COM**



WRITE IN

The writer of next issue's Question of the Month receives **two hardback popular science books**: *Amazing Worlds* and *Asteroids* **worth over £35!**

'I'm basically half-man, **half-turmeric**'

Lifelong runner James Pardey (54) relies on **Turmeric+** to keep doing what he loves. 'Running is my pressure release – my joyful thing.'

James has been running since childhood, but as the years passed, he started to wonder if his best days were behind him.

'I thought, crumbs, maybe my running days are over.' He tried Turmeric+, a supplement using a patented formula that makes turmeric's key active ingredient – curcumin – 30x more absorbable than standard turmeric.

Developed in the UK by Cambridge scientists and confirmed effective by more than 40 scientific studies, Turmeric+ is certified for use by athletes, and trusted by thousands of subscribers.

At first, James noticed no effect. But when he stopped taking it, the difference was clear. 'I was like, whoa! I hadn't realised it was making a difference.'

James took a subscription and hasn't missed a day since, 'I feel fantastic. I'm hammering 10-mile runs three times a week. It's transformative. As far as I'm concerned, I'll be taking it for the rest of my life.'

'Turmeric+ is **transformative**'

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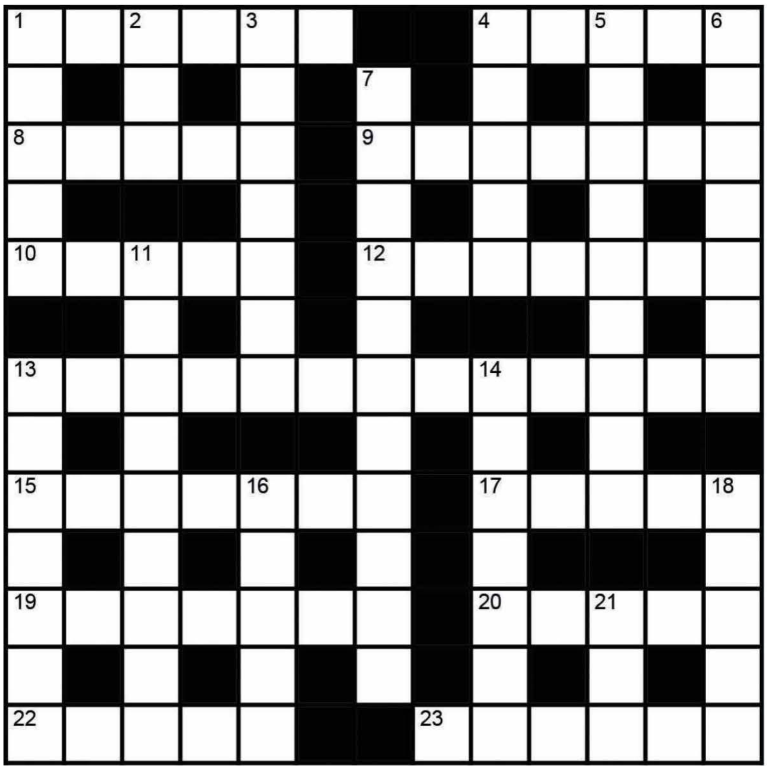
CROSSWORD

PENCILS AT THE READY!



ACROSS

1 Leave head of divinity to taper off (6)
4 Behold copper getting married to doctor (5)
8 Played game, wearing large sparkle (5)
9 A French dream about not carrying weapons (7)
10 Wonderful police officer, in short (5)
12 Sword for trim girl (7)
13 Meet corgi, terribly nasty, yet average (9,4)
15 Exaggerate concerning part of the play (7)
17 Fool gets by in canyon (5)
19 Team about to go in, multiplied by itself (7)
20 Thanks for every slender candle (5)
22 Groups of the French set off (5)
23 Connection to a game (6)

DOWN

1 Remove oxygen, say, for painter (5)
2 Hippies eating food (3)
3 Contrition concerning dots and dashes (7)
4 Plate, unusually, is sprung (5)
5 Composed car melody in a friendly way (9)
6 President's event (7)
7 Beauty making Cupid hurtle about (11)
11 In favour of awfully crude energy policy (9)
13 Grumbled the day after some game (7)
14 Caught last-mentioned rattling sound (7)
16 Scare involved some land (5)
18 Wait to play the first shot (5)
21 Some paper at home (3)

ANSWERS For the answers, visit **bit.ly/BBCFocusCW**
Please be aware the website address is case-sensitive.

NEXT ISSUE

PLANET KILLERS

The race is on to find deadly world-ending asteroids... before they find us first

GETTY IMAGES

PLUS

PALAEO PITFALLS

Eating like a caveman? Archaeologists uncover the real Stone Age menu

BOOST MODE

How to fight fatigue and stay productive through your afternoon energy dip

ON SALE 8 JULY

SF

BETTER LIVING THROUGH SCIENCE

BRAIN FREEZE

How to use one of the body's stress responses for better decision making

by **IAN TAYLOR**

Ian is a freelance science writer and the former deputy editor of BBC Science Focus.

Have you ever felt so stressed that you just sort of froze? It's a strange sensation. Your body goes still, you feel kind of numb but, at the same time, your senses are working overtime. You know you have to act soon, but it's as if there's a brake on the system.

If you know the feeling, there's a good chance that a moment of great stress triggered it. Psychological freezing is an adaptive defence response to stressful or dangerous situations. Like our fight-or-flight response, it evolved in animals as part of the automatic reaction our nervous system mounts when we experience either real or imagined threats.

When we freeze, our heart rate drops, our breathing slows and our blood pressure changes. Our pupils might dilate and our muscles can tense. A cascade of hormones and neurotransmitters surge through our bodies to prime us for action. It can all happen within seconds.

While fight-or-flight makes a certain amount of sense – to fight off an enemy or leg it from a predator – the freeze response seems a little counterproductive. It appears to momentarily overwhelm a person, making them incapable of acting or making a decision. In extreme cases, it may prevent them from moving at all.

But is that really all that's going on? Not according to Prof Karin Roelofs, a neuroscientist and clinical psychologist who studies freezing at Radboud University in the Netherlands.

"Many people think that freezing is a kind of shutdown of the system. Something happens and all of a sudden you're freezing and can't move," she says. "What we actually find is when you're in a threatening situation and you have to make rapid decisions, you're actually gaining more information. You're preparing your actions, you're better in perception and you're better in decision making."

In other words, freezing is something like an emergency flow state. It puts you 'in the zone' – you're alert, but not panicking. The parasympathetic nervous system kicks into action and gives you a degree of calm when you need it the most. "It's a very beneficial state," Roelofs says.

What's really intriguing is that she believes this system can be trained and even induced in a person. It can be a tool to pre-emptively deal with stress or to improve performance in a range of different scenarios. Roelofs offers two very different examples of people who are able to control the freeze response to their advantage.

One is living statues, those street performers you see in tourist hotspots who are able to stay almost unnaturally still. The other? Snipers. Military marksmen also stay incredibly still, while simultaneously making critical decisions about accuracy and when to take a shot in a life-or-death situation.

It's something Roelofs has replicated in the lab and her work has also been integrated into training for the Dutch police. She created a virtual reality shooting game where players "have to make decisions on a threat and we force them to keep their heart rate in a certain area."

"We found that the stronger the magnitude of the freezing [based on measurements of players' heart rates], the better they were at the game and the faster they were in their decisions."

It's tempting to think that if you freeze in a stressful situation, your response will be slower. The opposite is true because the freeze provides a moment of clarity, Roelofs says. "There is less noise in our brain. And we have increased perception. What we showed is that you're actually making better decisions faster, and you have a sharper view of the potential costs and benefits of your actions."

But let's say you're not a sniper, or don't spend your weekends as a living statue. What if you're about to take an exam or lead a big business meeting? What if you're an athlete needing a big performance? Those situations may not be life or death, but Roelofs has shown that the freeze response can still help, because it's not only triggered by physical threat, but in social situations as well. Her research found that even an angry face can cause a freeze response.

Exploit that response – learn to train and maintain it, Roelofs says. "The maintenance of this state is something we can train via breathing," she says. "Do the opposite of hyperventilating. Have a strong focus on a very slow exhalation. If we can stay in the same rhythm, we keep the heart rate low, increase parasympathetic activity and have less noise in the brain."

Instead of feeling out of control, you can master it and – sniper or not – take your best shot. **SF**

"FREEZING IS SOMETHING LIKE AN EMERGENCY FLOW STATE. IT PUTS YOU 'IN THE ZONE'"

ILLUSTRATION: MARTA LANUZA

This was Sylvia's promise to you...

A generation ago, a woman named Sylvia made a promise. As a doctor's secretary, she'd watched stroke destroy the lives of so many people. She was determined to make sure we could all live in a world where we're far less likely to lose our lives to stroke.

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Sylvia changed the story for us all. Now it's our turn to change the story for those who'll come after us.

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